Atlas of July Oceanographic Conditions in the Northeast Pacific Ocean, 1961-64

By R. W. Owen, Jr.

SPECIAL SCIENTIFIC REPORT—FISHERIES No. 549

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
John A. Carver, Jr., *Under Secretary*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife and Parks*
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, *Commissioner*
BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, *Director*

Atlas of July Oceanographic Conditions in the Northeast Pacific Ocean, 1961-64

By

R. W. Owen, Jr.

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 549

Washington, D.C.
January 1967

CONTENTS

	Page
Introduction	1
Environment and catch	2
Acknowledgments	2
Literature cited	3

FIGURES

	Page
Figure 1.--Distribution of temperature at 10 m., July 1961. Contour interval is 0.5° C. except where shaded	4
Figure 2.--Distribution of temperature at 10 m., July 1962. Contour interval is 0.5° C. except where shaded	5
Figure 3.--Distribution of temperature at 10 m., July 1963. Contour interval is 0.5° C. except where shaded	6
Figure 4.--Distribution of temperature at 10 m., July 1964. Contour interval is 0.5° C. except where shaded	7
Figure 5.--Distribution of salinity at 10 m., July 1961. Contour interval is 0.5 p.p.t. except where shaded	8
Figure 6.--Distribution of salinity at 10 m., July 1962. Contour interval is 0.5 p.p.t. except where shaded	9
Figure 7.--Distribution of salinity at 10 m., July 1963. Contour interval is 0.5 p.p.t.	10
Figure 8.--Distribution of salinity at 10 m., July 1964. Contour interval is 0.5 p.p.t.	11
Figure 9.--Horizontal distribution of density at 10 m., July 1961. Contour interval is 0.5 σ_t unit	12
Figure 10.--Horizontal distribution of density at 10 m., July 1962. Contour interval is 0.5 σ_t unit	13
Figure 11.--Horizontal distribution of density at 10 m., July 1963. Contour interval is 0.5 σ_t unit	14
Figure 12.--Horizontal distribution of density at 10 m., July 1964. Contour interval is 0.5 σ_t unit except where shaded	15
Figure 13.--Horizontal distribution of oxygen concentration at 10 m., July 1961. Contour interval is 0.2 ml./l. except where shaded	16
Figure 14.--Horizontal distribution of oxygen concentration at 10 m., July 1962. Contour interval is 0.2 ml./l.	17
Figure 15.--Horizontal distribution of oxygen concentration at 10 m., July 1963. Contour interval is 0.2 ml./l. except where shaded	18
Figure 16.--Horizontal distribution of oxygen concentration at 10 m., July 1964. Contour interval is 0.2 ml./l. except where shaded	19
Figure 17.--Horizontal distribution of temperature at 100 m., July 1961. Contour interval is 0.25° C. except where shaded	20
Figure 18.--Horizontal distribution of temperature at 100 m., July 1962. Contour interval is 0.25° C.	21
Figure 19.--Horizontal distribution of temperature at 100 m., July 1963. Contour interval is 0.25° C.	22
Figure 20.--Horizontal distribution of temperature at 100 m., July 1964. Contour interval is 0.25° C.	23
Figure 21.--Horizontal distribution of salinity at 100 m., July 1961. Contour interval is 0.2 p.p.t.	24
Figure 22.--Horizontal distribution of salinity at 100 m., July 1962. Contour interval is 0.2 p.p.t.	25
Figure 23.--Horizontal distribution of salinity at 100 m., July 1963. Contour interval is 0.2 p.p.t.	26
Figure 24.--Horizontal distribution of salinity at 100 m., July 1964. Contour interval is 0.2 p.p.t.	27
Figure 25.--Horizontal distribution of density at 100 m., July 1961. Contour interval is 0.25 σ_t unit	28

Page

Figure 26.--Horizontal distribution of density at 100 m., July 1962. Contour interval is 0.25 σ_t unit. 29
Figure 27.--Horizontal distribution of density at 100 m., July 1963. Contour interval is 0.25 σ_t unit. 30
Figure 28.--Horizontal distribution of density at 100 m., July 1964. Contour interval is 0.25 σ_t unit. 31
Figure 29.--Horizontal distribution of oxygen concentration at 100 m., July 1961. Contour interval is 0.5 ml./l. 32
Figure 30.--Horizontal distribution of oxygen concentration at 100 m., July 1962. Contour interval is 0.5 ml./l. 33
Figure 31.--Horizontal distribution of oxygen concentration at 100 m., July 1963. Contour interval is 0.5 ml./l. 34
Figure 32.--Horizontal distribution of oxygen concentration at 100 m., July 1964. Contour interval is 0.5 ml./l. 35
Figure 33.--Horizontal distribution of temperature at 500 m., July 1961. Contour interval is 0.2° C.. 36
Figure 34.--Horizontal distribution of temperature at 500 m., July 1962. Contour interval is 0.2° C.. 37
Figure 35.--Horizontal distribution of temperature at 500 m., July 1963. Contour interval is 0.2° C.. 38
Figure 36.--Horizontal distribution of temperature at 500 m., July 1964. Contour interval is 0.2° C.. 39
Figure 37.--Horizontal distribution of salinity at 500 m., July 1961. Contour interval is 0.05 p.p.t. 40
Figure 38.--Horizontal distribution of salinity at 500 m., July 1962. Contour interval is 0.05 p.p.t. 41
Figure 39.--Horizontal distribution of salinity at 500 m., July 1963. Contour interval is 0.05 p.p.t. 42
Figure 40.--Horizontal distribution of salinity at 500 m., July 1964. Contour interval is 0.05 p.p.t. 43
Figure 41.--Horizontal distribution of density at 500 m., July 1961. Contour interval is 0.025 σ_t unit 44
Figure 42.--Horizontal distribution of density at 500 m., July 1962. Contour interval is 0.025 σ_t unit 45
Figure 43.--Horizontal distribution of density at 500 m., July 1963. Contour interval is 0.025 σ_t unit 46
Figure 44.--Horizontal distribution of density at 500 m., July 1964. Contour interval is 0.025 σ_t unit except where shaded. 47
Figure 45.--Horizontal distribution of oxygen concentration at 500 m., July 1961. Contour interval is 0.2 ml./l. 48
Figure 46.--Horizontal distribution of oxygen concentration at 500 m., July 1962. Contour interval is 0.2 ml./l. 49
Figure 47.--Horizontal distribution of oxygen concentration at 500 m., July 1963. Contour interval is 0.2 ml./l. 50
Figure 48.--Horizontal distribution of oxygen concentration at 500 m., July 1964. Contour interval is 0.2 ml./l. 51
Figure 49.--Vertical profiles of temperature in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic 52
Figure 50.--Vertical profiles of temperature in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic 53
Figure 51.--Vertical profiles of temperature in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic 54
Figure 52.--Vertical profiles of temperature in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic 55
Figure 53.--Vertical profiles of salinity in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. except where shaded. Depth scale is logarithmic. 56

Page

Figure 54.--Vertical profiles of salinity in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. Depth scale is logarithmic. 57
Figure 55.--Vertical profiles of salinity in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. Depth scale is logarithmic. 58
Figure 56.--Vertical profiles of salinity in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. except where shaded. Depth scale is logarithmic. 59
Figure 57.--Vertical profiles of density in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit except where shaded. Depth scale is logarithmic . 60
Figure 58.--Vertical profiles of density in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit. Depth scale is logarithmic 61
Figure 59.--Vertical profiles of density in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit. Depth scale is logarithmic 62
Figure 60.--Vertical profiles of density in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit except where shaded. Depth scale is logarithmic . 63
Figure 61.--Vertical profile of oxygen concentration along lat. 44° N., July 1961. Contour interval is 0.5 ml./1. Depth scale is logarithmic. 64
Figure 62.--Depth of the upper mixed layer, July 1961. Contour interval is 10 m. 65
Figure 63.--Depth of the upper mixed layer, July 1962. Contour interval is 10 m. 66
Figure 64.--Depth of the upper mixed layer, July 1963. Contour interval is 10 m. 67
Figure 65.--Depth of the upper mixed layer, July 1964. Contour interval is 10 m. 68
Figure 66.--Geopotential topography of the sea surface relative to 500 decibars, July 1961. Contour interval is 2 dynamic cm. 69
Figure 67.--Geopotential topography of the sea surface relative to 500 decibars, July 1962. Contour interval is 2 dynamic cm. 70
Figure 68.--Geopotential topography of the sea surface relative to 500 decibars, July 1963. Contour interval is 2 dynamic cm. 71
Figure 69.--Geopotential topography of the sea surface relative to 500 decibars, July 1964. Contour interval is 2 dynamic cm. 72
Figure 70.--Distribution of chlorophyll a concentration at the sea surface, July 1961. Contour interval (between solid lines) is 0.1 mg./m ^{3} 73
Figure 71.--Distribution of chlorophyll a concentration at the sea surface, July 1962. Contour interval (between solid lines) is 0.1 mg./m ^{3} 74
Figure 72.--Distribution of chlorophyll a concentration at the sea surface, July 1963. Contour interval (between solid lines) is 0.1 mg./m ^{3} 75
Figure 73.--Distribution of chlorophyll a concentration at the sea surface, July 1964. Contour interval (between solid lines) is 0.1 mg./m ^{3} 76
Figure 74.--Vertical profiles of chlorophyll a concentration, July 1964. Profiles are along track lines represented by uppermost line of each section. Contour interval is 0.1 mg./m ^{3} 77
Figure 75.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1961. Day and month given below or beside track line segments 78
Figure 76.--Albacore catches (boxed numerals) by M/V John N. Cobb and R/V Brown Bear and lateral plume limits (32.2 p.p.t. isosal) in July 1962. Day and month given below or beside track line segments 79
Figure 77.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1963. Day and month given below or beside track line segments 80
Figure 78.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1964. Day and month given below or beside track line segments 81
Figure 79.--Cruise track and station locations on M/V John N. Cobb Cruise 51, July 1961 82

Page

Figure 80.--Cruise track and station locations on M/V *John N. Cobb* Cruise 55, July 1962 83

Figure 81.--Cruise track and station locations on M/V *John N. Cobb* Cruise 60, July 1963 84

Figure 82.--Cruise track and station locations on M/V *John N. Cobb* Cruise 66, July 1964 85

Atlas of July Oceanographic Conditions in the Northeast Pacific Ocean, 1961-64

BY

R. W. OWEN, JR., Oceanographer

Bureau of Commercial Fisheries Tuna Resources Laboratory
La Jolla, Calif. 92037

ABSTRACT

An atlas of July oceanographic conditions in 1961-64 is presented for the region bounded by the coast of Oregon-Washington and long. 132° W. The atlas consists of charts that show distributions of temperature, salinity, density, oxygen concentration, thickness of mixed layer, dynamic height, chlorophyll *a* concentration, and catch of albacore, *Thunnus alalunga* (Bonnaterre), at the time of year when albacore first become available to the commercial fishery of the region. Some remarks on the albacore catch and the environment are included.

INTRODUCTION

Marked variation of the annual commercial catch of albacore, *Thunnus alalunga* (Bonnaterre), characterizes the fishery off the coast of Washington and Oregon. This variation, due in part to changes in fishing effort, appears to be related to the nature of the environment as well (Alverson, 1961; Johnson, 1962). Adverse economic effects of catch variation and the desire for efficient use of the albacore resource have prompted a series of cruises to characterize the environment that albacore encounter annually off the west coast of North America, and to examine relations between albacore and measurable characteristics of this environment. The series was a cooperative venture of the Bureau of Commercial Fisheries Tuna Resources Laboratory, La Jolla, Calif., with the Bureau's Exploratory Fishing and Gear Research Base, Seattle, Wash. The survey vessel, M/V *John N. Cobb*, was operated by the latter agency.

Albacore usually first become available to the commercial fishery off Oregon and Washington in mid-July. The present work is an atlas of oceanographic conditions in the region off the coast of Oregon and Washington during July in 1961-64. The atlas contains charts of horizontal distributions of temperature, salinity, density, and oxygen concentration in the surface layer (figs. 1-16), at 100 m. depth (figs. 17-32), and at 500 m. depth (figs. 33-48), as well as some vertical sections of these properties (figs. 49-61). Corresponding distribution charts are given that depict mixed-layer depth (figs. 62-65), geopotential topography of the sea surface (figs. 66-69), chlorophyll *a* at the sea surface (figs. 70-73), and vertical profiles of chlorophyll *a* in July 1964 (fig. 74). For comparison, July distributions of albacore catch by research vessels are depicted (figs. 75-78).

These presentations are intended for use by oceanographers and fishery scientists, as well as for use as a supplement to a description of oceanographic processes that produce and modify the distribution of variables and their relation to the albacore fishery (Owen, manuscript).[1]

Exploratory fishing and albacore-oceanography cruises off Washington and Oregon previous to 1961 have been listed by Owen (1963). Since 1961, no other reports have been published, although albacore trolling has been conducted on oceanographic cruises by R/V *Brown Bear* of the Department of Oceanography, University of Washington, and by R/V *Acona*, of the Department of Oceanography, Oregon State University, as well as on M/V *Cobb* cruises. In addition, the Fish Commission of Oregon made exploratory fishing cruises early in the albacore season in July 1962 and July 1964.[2]

---

[1] Owen, Robert W. Manuscript. Oceanographic conditions off the American Pacific Northwest and their relation to the albacore fishery.

[2] Unpublished reports of the Fish Commission of Oregon, dated July 27, 1962, and August 20, 1964.

Cruise tracks of M/V Cobb were planned in cooperation with oceanographers at the University of Washington and Oregon State University; in this way efficient coverage of much larger areas was possible. Basic oceanographic data are to be published by the collecting agencies. The figures presented here, however, were constructed from all available July data in the respective years. July station locations of vessels taking oceanographic data in the area in 1961-64 are depicted in figures 79-82 to specify coverage by each of the participating groups. Oceanographic and exploratory fishing data collected aboard M/V Cobb in July 1961, together with a statement of methods, were summarized by Owen (1963). Observations made in 1962-64 were summarized by Owen (manuscript).[3] Interpretations in this publication do not necessarily constitute concurrence by members of the other agencies.

ENVIRONMENT AND CATCH

Oceanographic conditions and their effect upon the albacore fishery off Washington and Oregon are discussed in a separate paper (Owen, manuscript).[4] Some of the patterns of property distribution are of sufficient interest, however, to warrant comment here.

One of the most striking modifications of the subarctic character of the study region is provided by fresh-water effluent, principally from the Columbia River. This effluent is transported generally southwest in summer from its source at 47.2° N., and, through lateral mixing, produces the plumelike distribution of salinity shown in figures 5-8. This low-salinity plume extends to depths in excess of 30 m. (figs. 53-56); if one assumes the plume limit to be defined by the 32.2 p.p.t. isosal, the plume extends more than 200 nautical miles (370 km.) offshore and 400 nautical miles (740 km.) south of its main source. The limits of the plume thus largely exceed the present range of the fishery for albacore off Oregon and Washington, with the exception of 1964, when the July plume was greatly constrained (fig. 8). The plume is not as well defined off Washington in summer, however, because it is not wholly derived from Columbia River effluent but from weaker or more distant sources as well.

Distributions of near-surface temperature appear to be influenced by the presence of the plume. Either reduced depth of the mixed layer or diminished heat flux through the thermocline, both associated with large density gradients near the lower plume limits, would produce the higher plume temperatures shown in figures 1-4.

A second conspicuous modification of near-surface waters is produced by nearshore upwelling of colder, more saline water. Upwelling, the characteristic response to the wind-driven seaward displacement of surface water that accompanies the spring shift in wind direction from southwest to northwest, dominates other processes in the region between plume and coast to produce the cold ($T < 14^{\circ}$ C.), saline ($S > 32.2$ p.p.t.) near-surface water shown in figures 1-4 and 5-8. Subsurface effects of upwelling are indicated by the sharp coastward ascent of temperature and salinity isopleths depicted in the vertical profiles of these variables (figs. 49-52 and 53-56).

Comparison of the distributions of albacore catches from the Cobb presented in figures 75-78, with patterns of salinity distribution reveals that the albacore catch is greater near and within the plume. This relation suggests either that albacore in commercial quantities first enter the plume region from the south, then proceed offshore, or that the plume region serves in some way to concentrate albacore entering from the west as well as the south. Support for the latter possibility is indicated by results of albacore fishing by U.S. Navy picket vessels some 200 nautical miles (270 km.) west of the study area (Flittner, 1961, 1963, 1964, and personal communication). Catches from picket vessels which occurred before the first Cobb catch in each year, show that albacore are present to the west of the plume region in July. The distribution of albacore is thus indicated to be continuous between these catch sites, so that albacore may enter the Oregon-Washington fishery from the west as well as from the south.

One manner in which the plume may act to produce higher concentrations of albacore is through its effect on mixed-layer temperature. The constraint of heat in the plume results in higher temperatures than at comparable latitudes offshore. These temperatures and the cooling effect of coastal upwelling produce a ridge of warmer water that corresponds with the plume itself. A region of more favorable environment may thus arise in which albacore tend to remain and to form larger, more fishable schools.

ACKNOWLEDGMENTS

Special acknowledgment is made to the Data Collection and Processing Group of Scripps Institution of Oceanography for their part in initial processing of data from hydrographic casts, and to the Department of Oceanography, University of Washington, for their analysis of Cobb salinity samples in 1962. The following

---

[3] Owen, Robert W. Manuscript. Northeast Pacific albacore-oceanography data, 1962-64.

[4] Owen, Robert W. Manuscript. Oceanographic conditions off the American Pacific Northwest and their relation to the albacore fishery.

people furthered this and subsequent work by their direct assistance in data collection, processing, and preparation: David K. Justice, Lorraine C. Downing, Arthur W. Hester, Jan B. Lawson, and James Pine. Bruce Wyatt, of Oregon State University, and C. M. Love,[5] of the University of Washington, cooperated in scheduling cruise tracks and in the exchange of resulting data.

[5]Now with the Inter-American Tropical Tuna Commission, La Jolla, Calif.

LITERATURE CITED

ALVERSON, DAYTON L.
1961. Ocean temperatures and their relation to albacore tuna (Thunnus germo) distribution in waters off the coast of Oregon, Washington and British Columbia. J. Fish. Res. Bd. Can. 18(6): 1145-1152.

FLITTNER, GLENN A.
1961. Cooperative trolling program, 1961. Calif. Fishery Market News Monthly Summary, Part II - Fishing Information, Dec. 1961, p. 1-8.

________.
1963. Review of the 1962 seasonal movement of albacore tuna off the Pacific coast of the United States. Com. Fish. Rev. 25(4): 7-13.

________.
1964. Review of the movement of albacore tuna off the Pacific coast in 1963. Com. Fish. Rev. 26(12): 13-19.

JOHNSON, JAMES H.
1962. Sea temperatures and the availability of albacore off the coasts of Oregon and Washington. Trans. Amer. Fish. Soc. 91(3): 269-274.

OWEN, R. W., JR.
1963. Northeast Pacific albacore oceanography surveys, 1961. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 444, iv + 35 p.

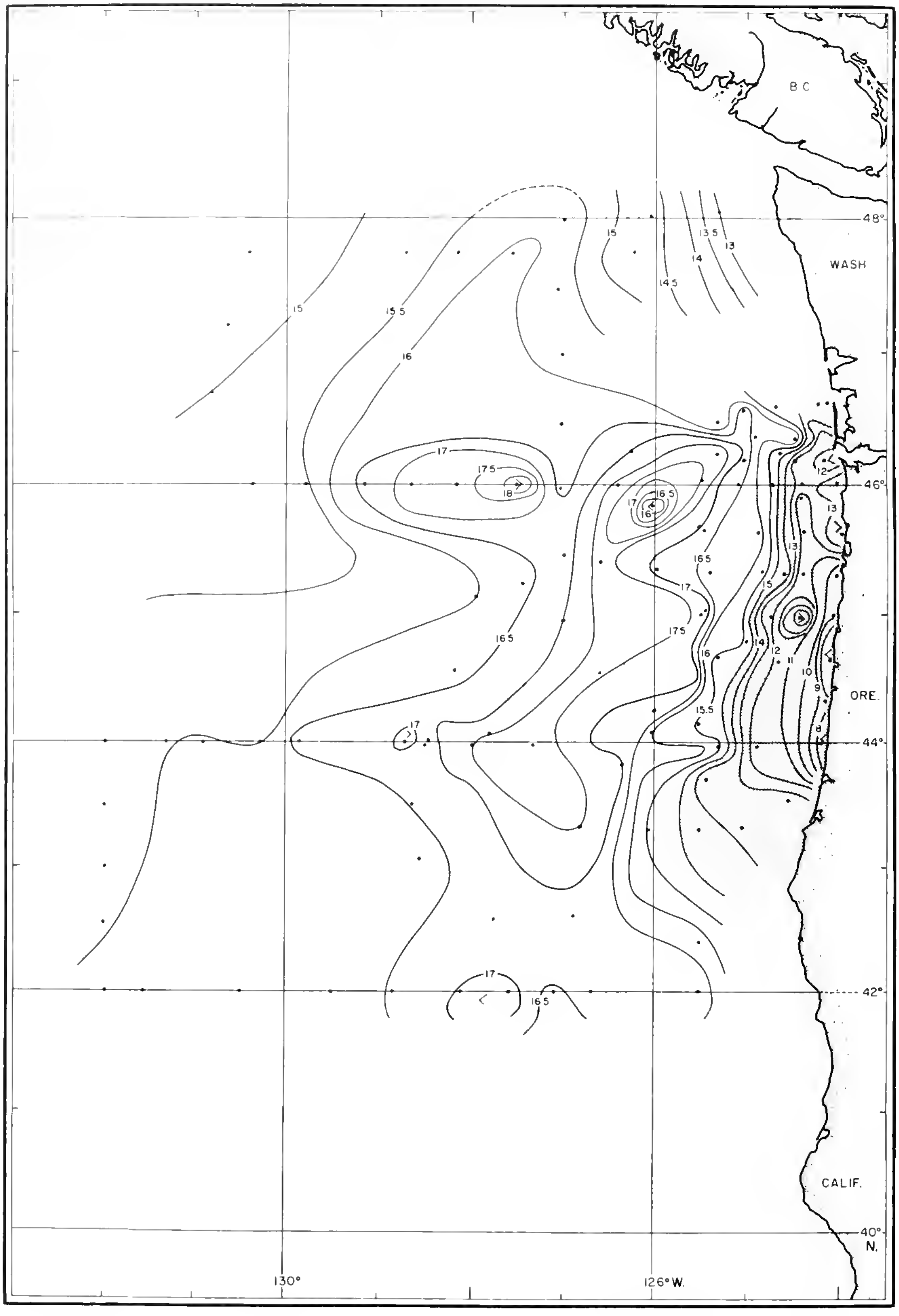

Figure 1.--Distribution of temperature at 10 m., July 1961. Contour interval is 0.5° C. except where shaded.

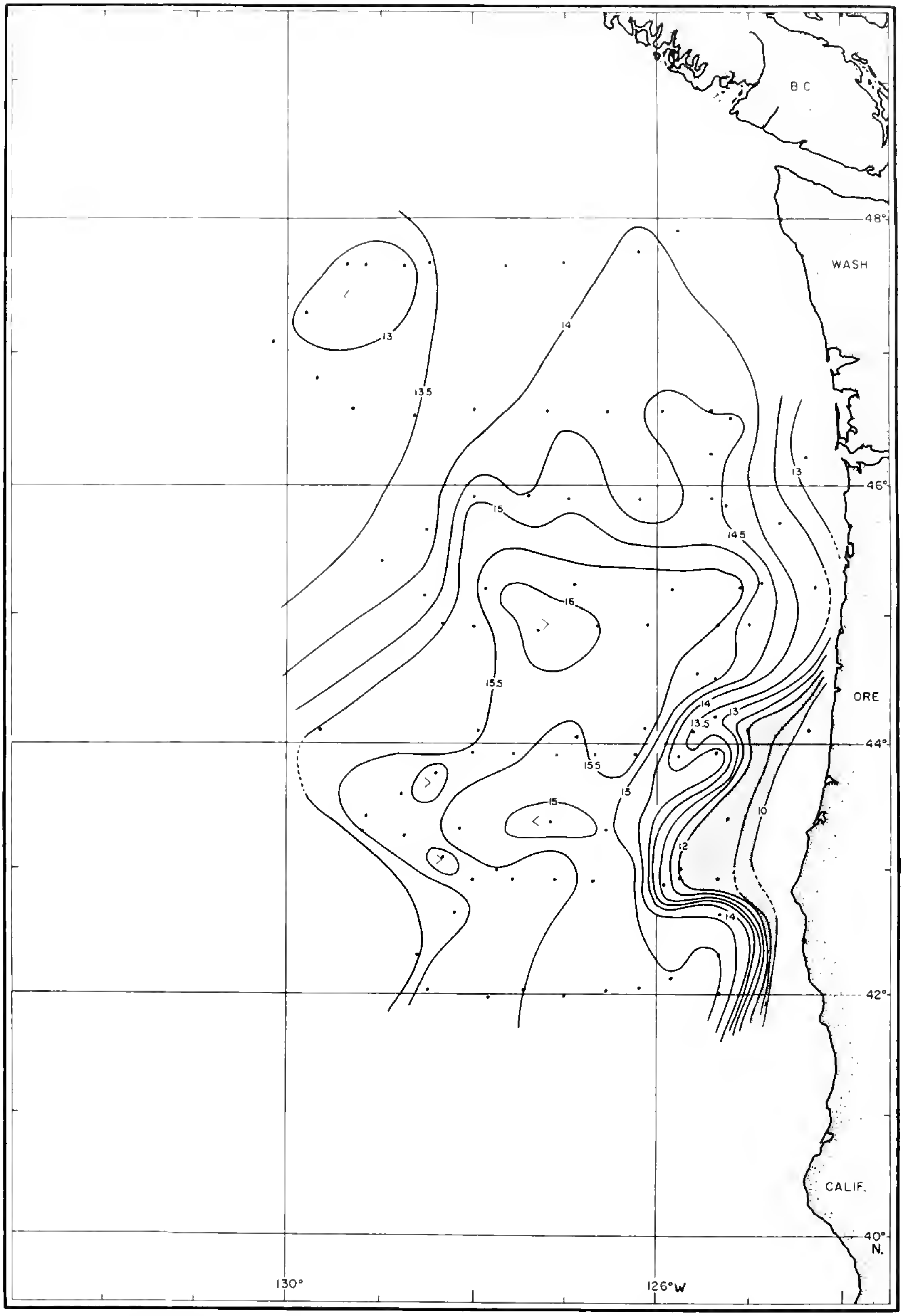

Figure 2.--Distribution of temperature at 10 m., July 1962. Contour interval is 0.5° C. except where shaded.

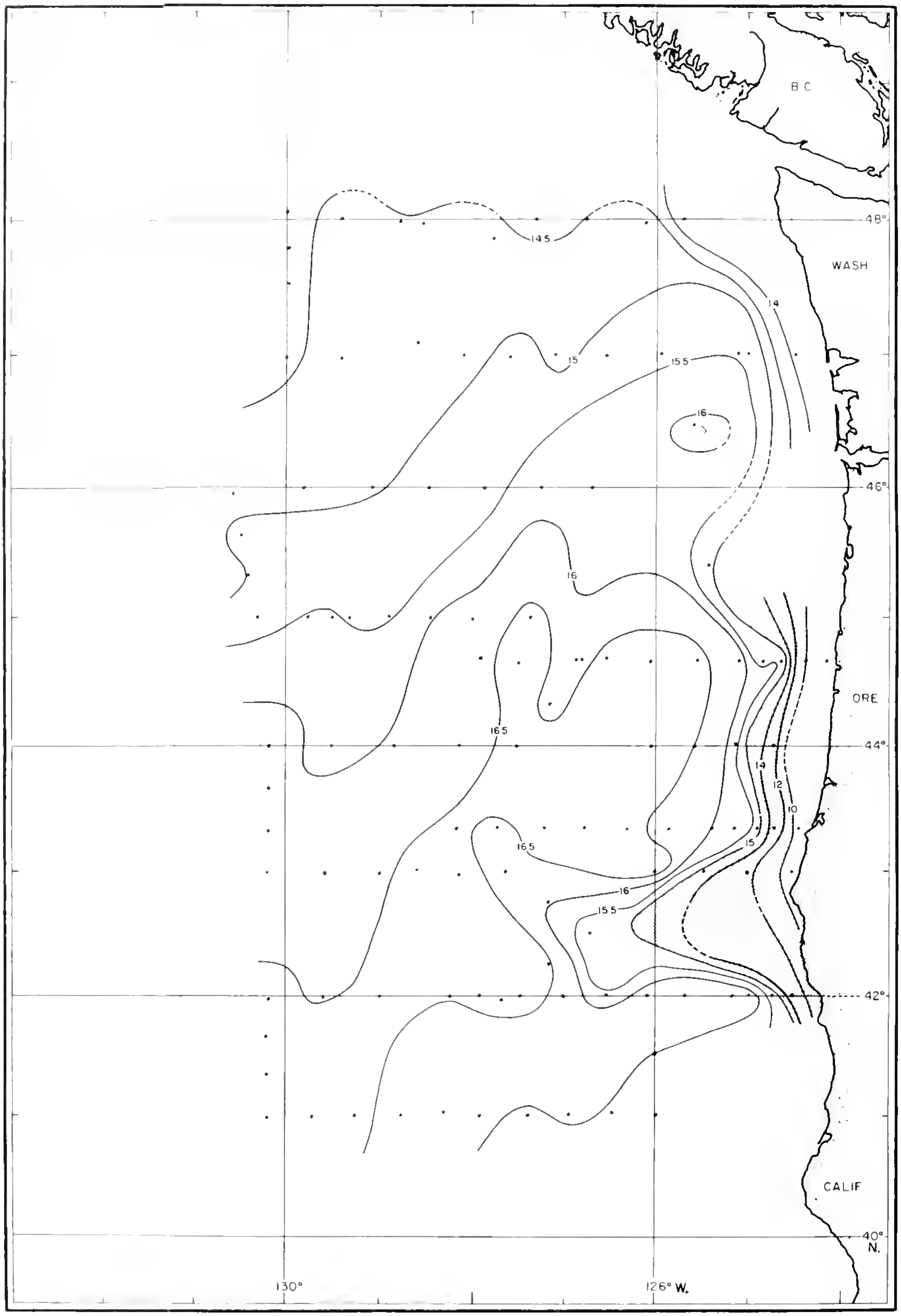

Figure 3.--Distribution of temperature at 10 m., July 1963. Contour interval is 0.5° C. except where shaded.

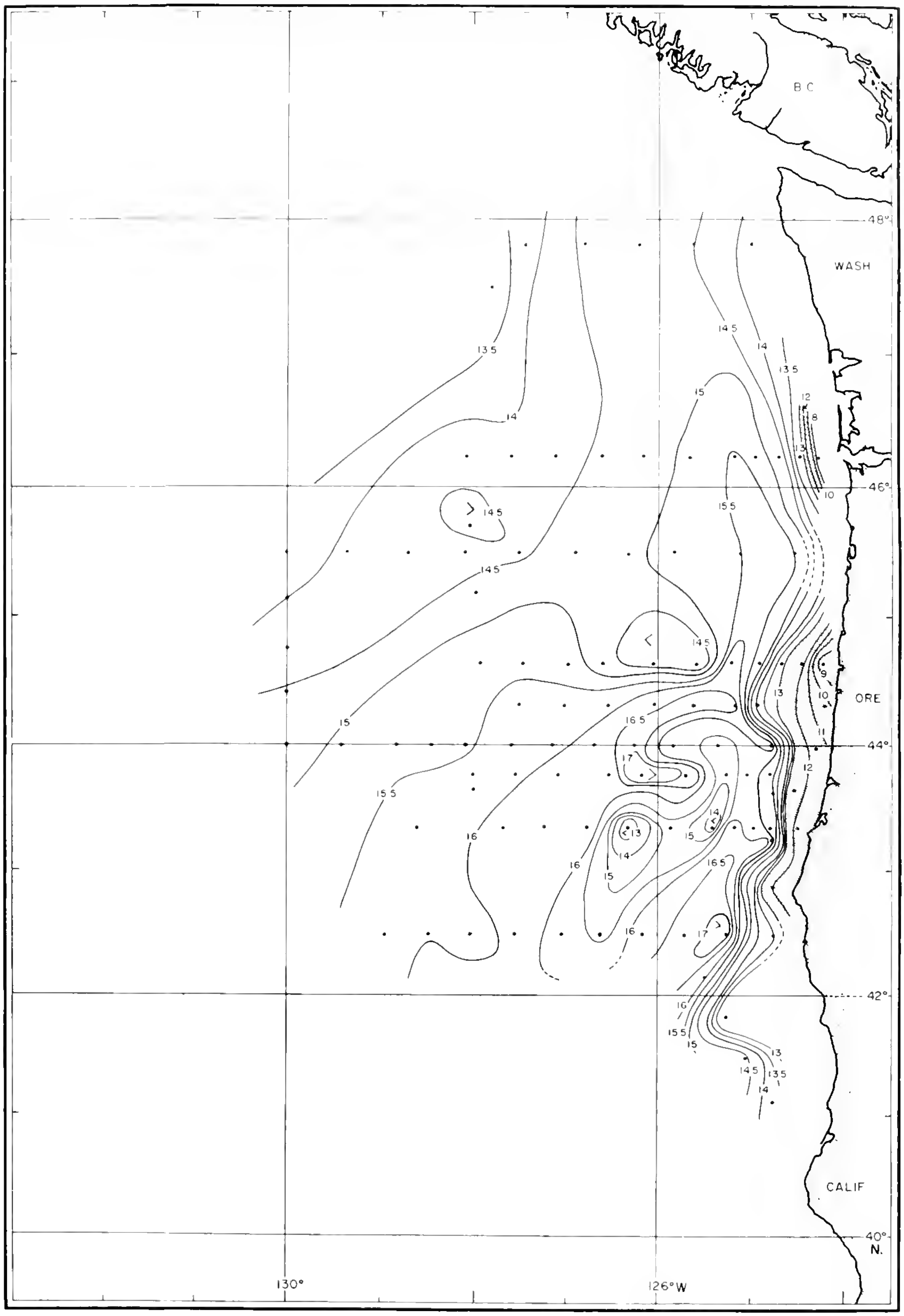

Figure 4.--Distribution of temperature at 10 m., July 1964. Contour interval is 0.5° C. except where shaded.

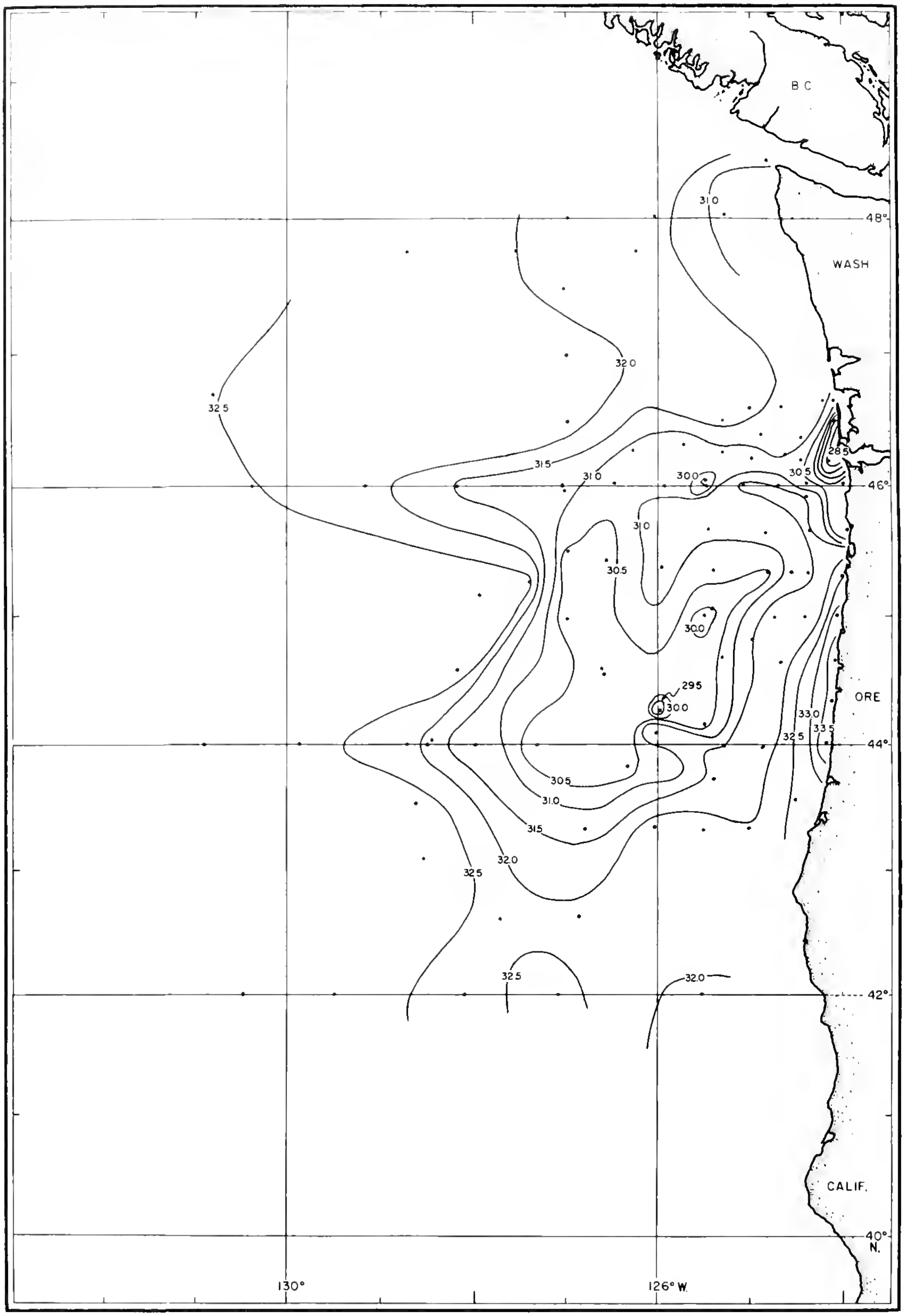

Figure 5.--Distribution of salinity at 10 m., July 1961. Contour interval is 0.5 p.p.t. except where shaded.

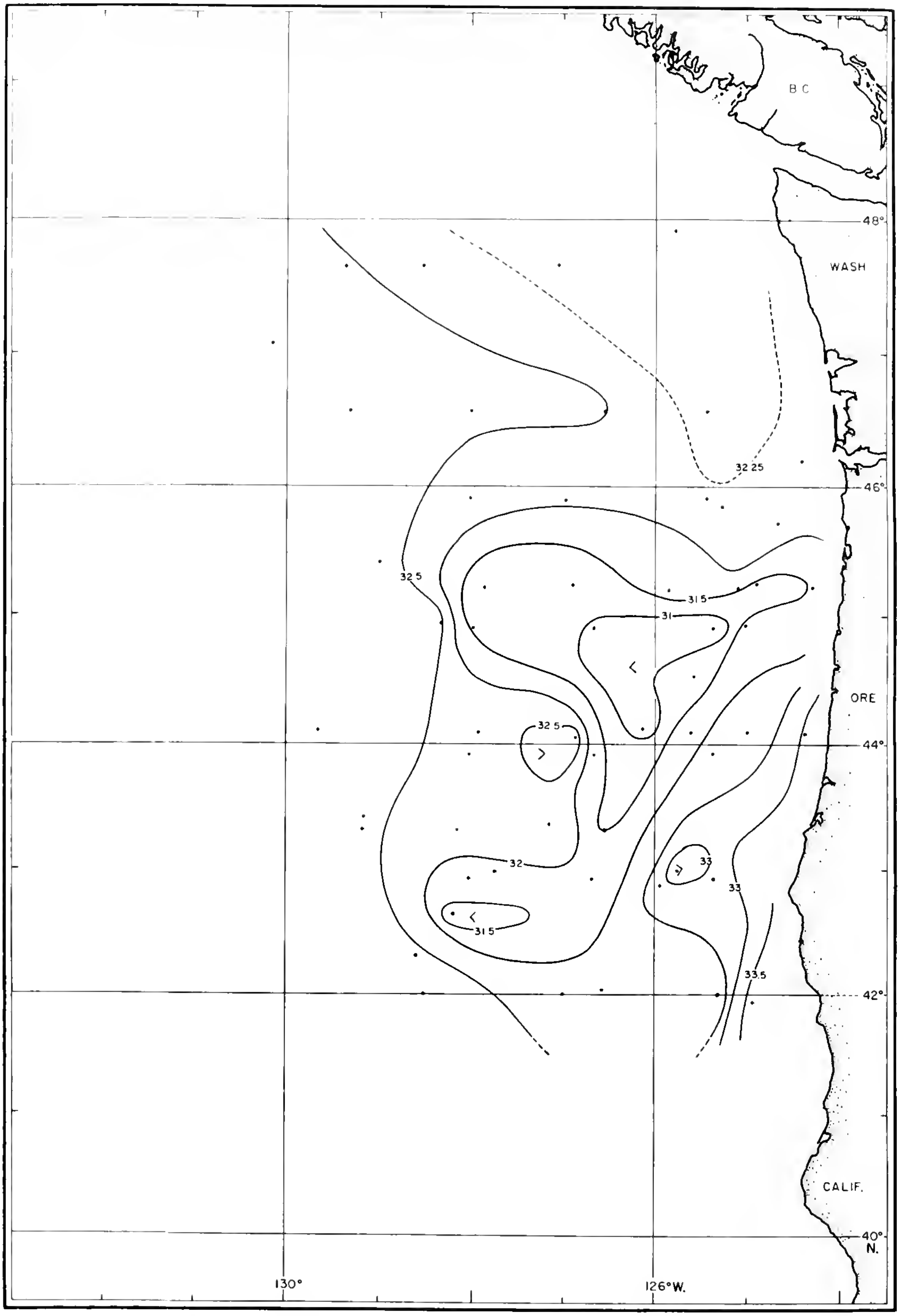

Figure 6.--Distribution of salinity at 10 m., July 1962. Contour interval is 0.5 p.p.t. except where shaded.

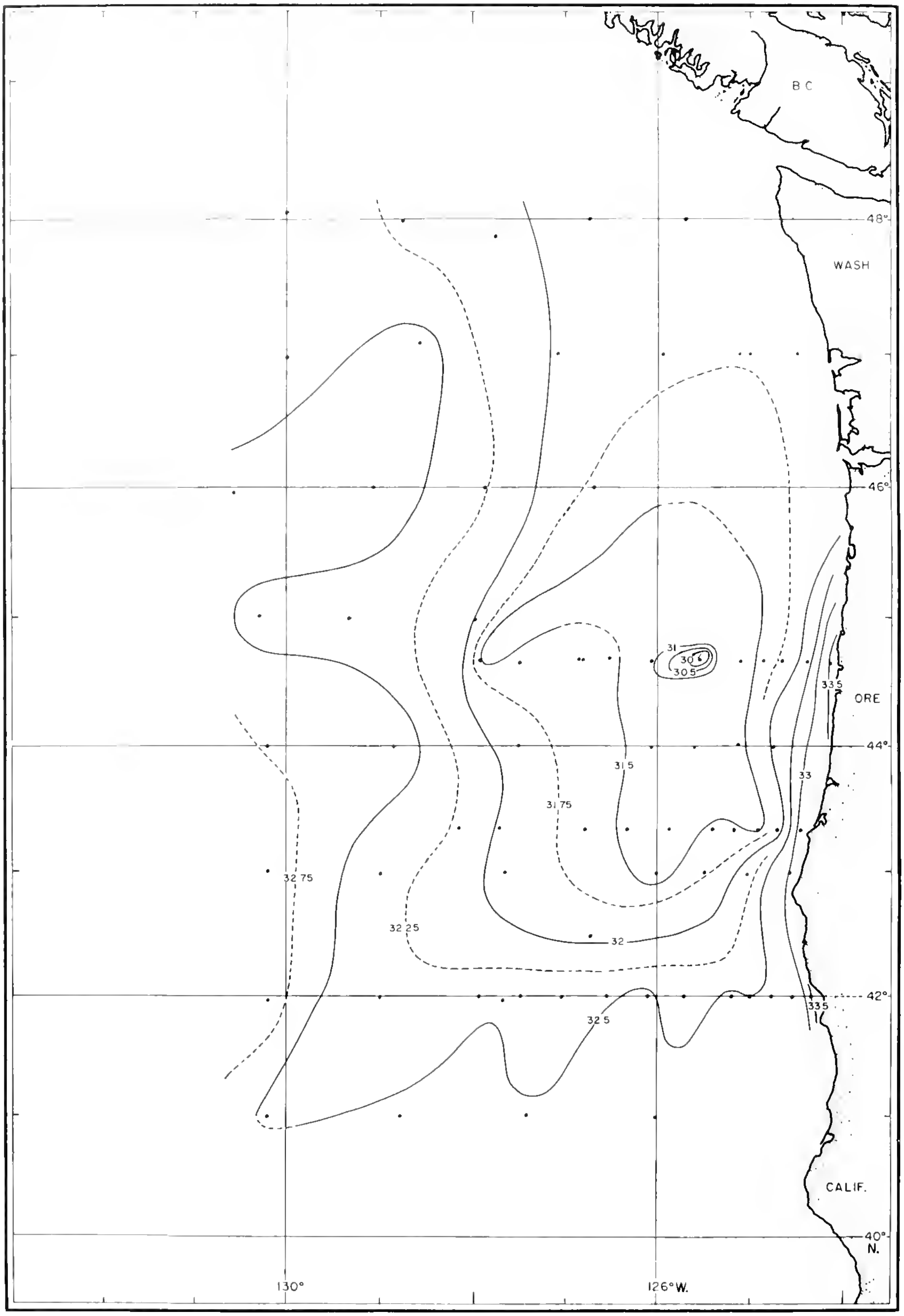

Figure 7.--Distribution of salinity at 10 m., July 1963. Contour interval is 0.5 p.p.t.

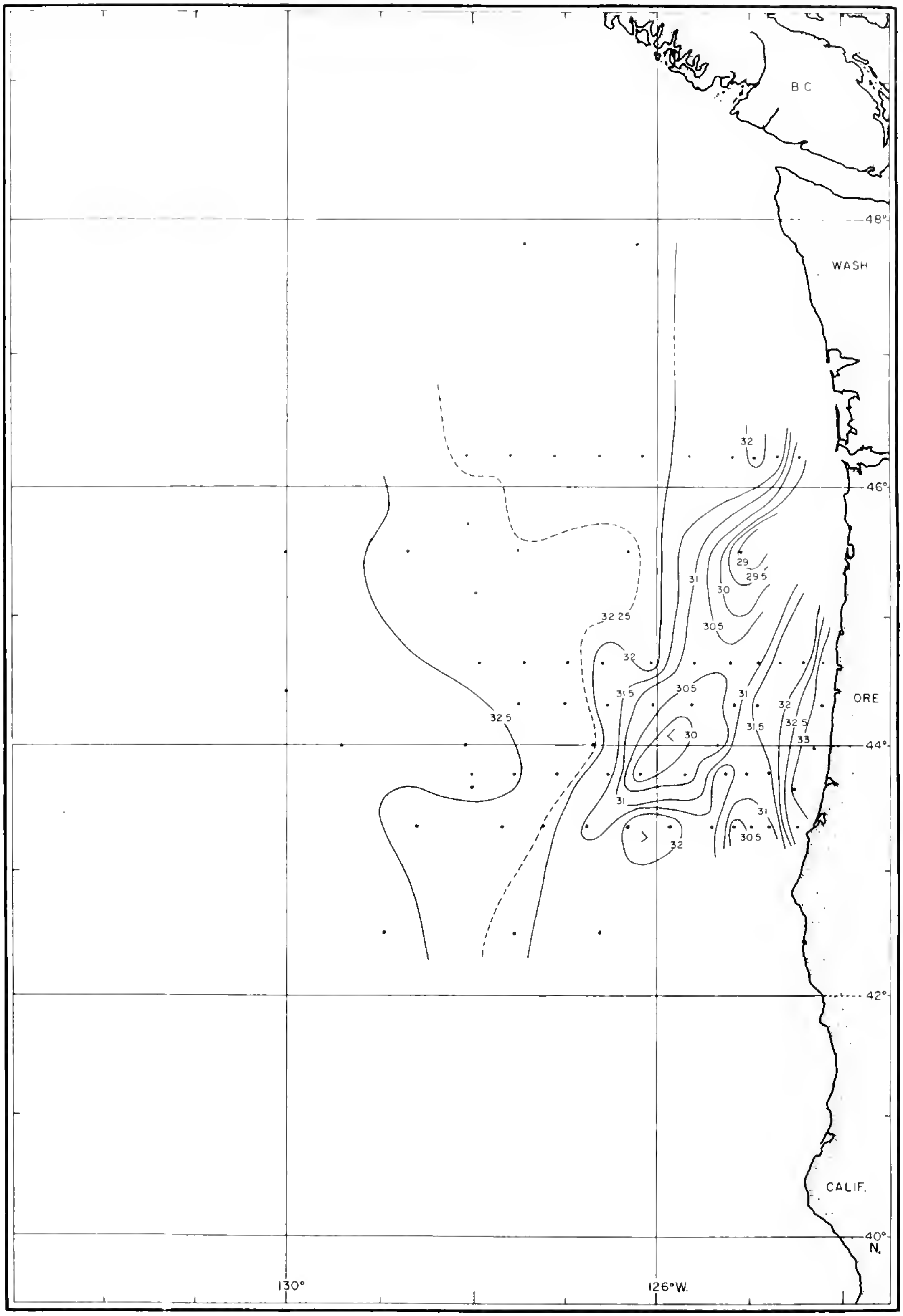

Figure 8.--Distribution of salinity at 10 m., July 1964. Contour interval is 0.5 p.p.t.

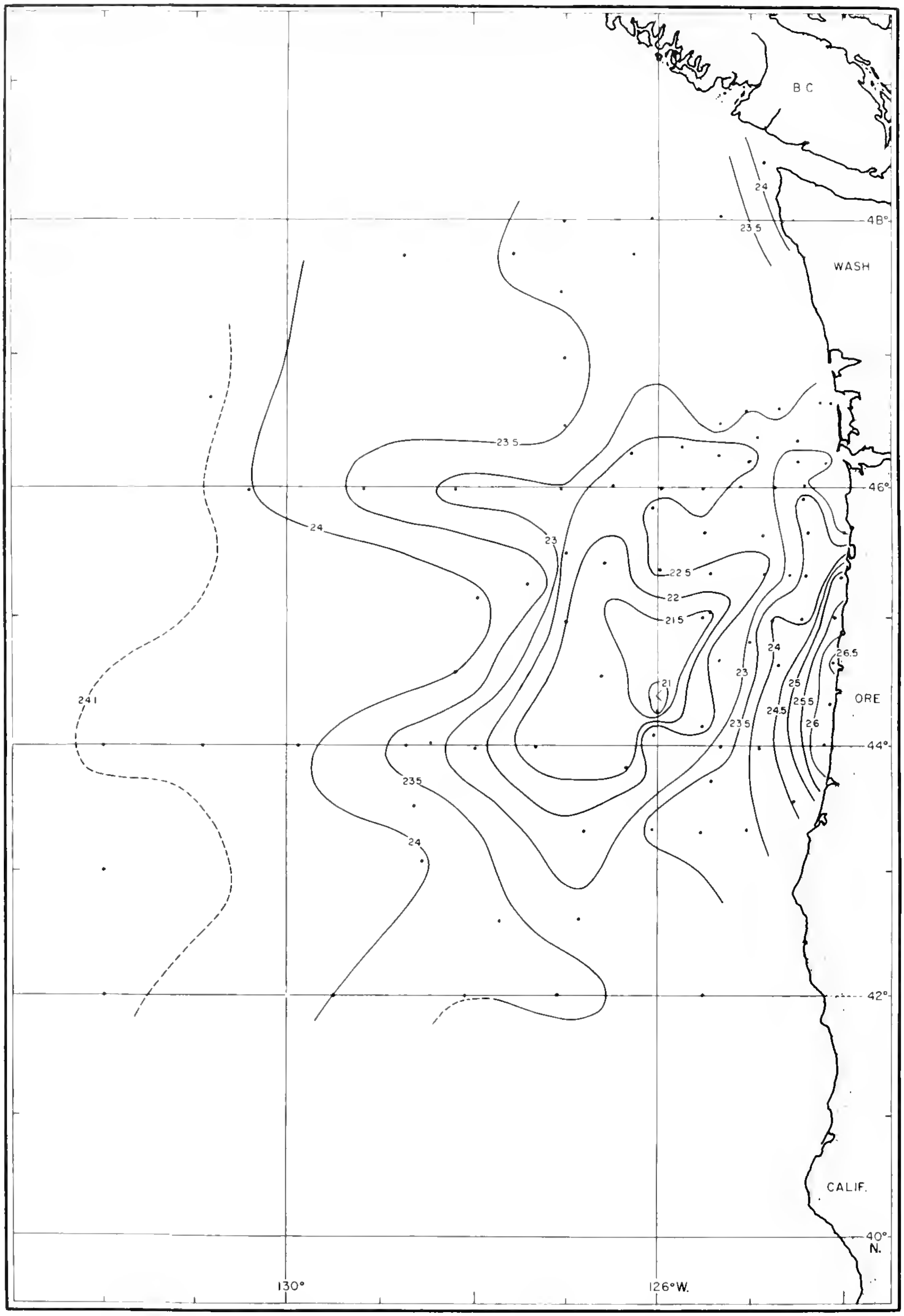

Figure 9.--Horizontal distribution of density at 10 m., July 1961. Contour interval is 0.5 σ_t unit.

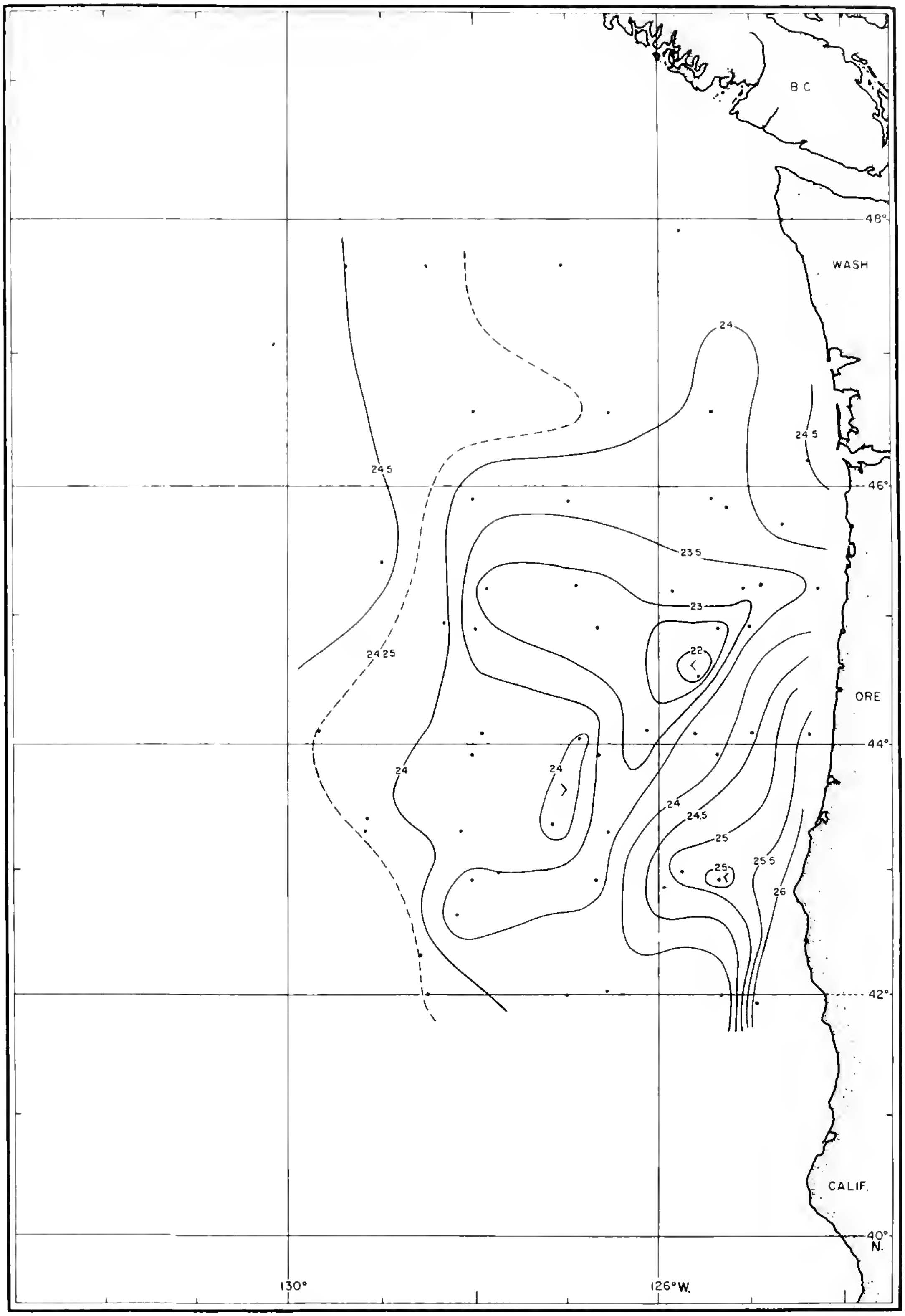

Figure 10.--Horizontal distribution of density at 10 m., July 1962. Contour interval is 0.5 σ_t unit.

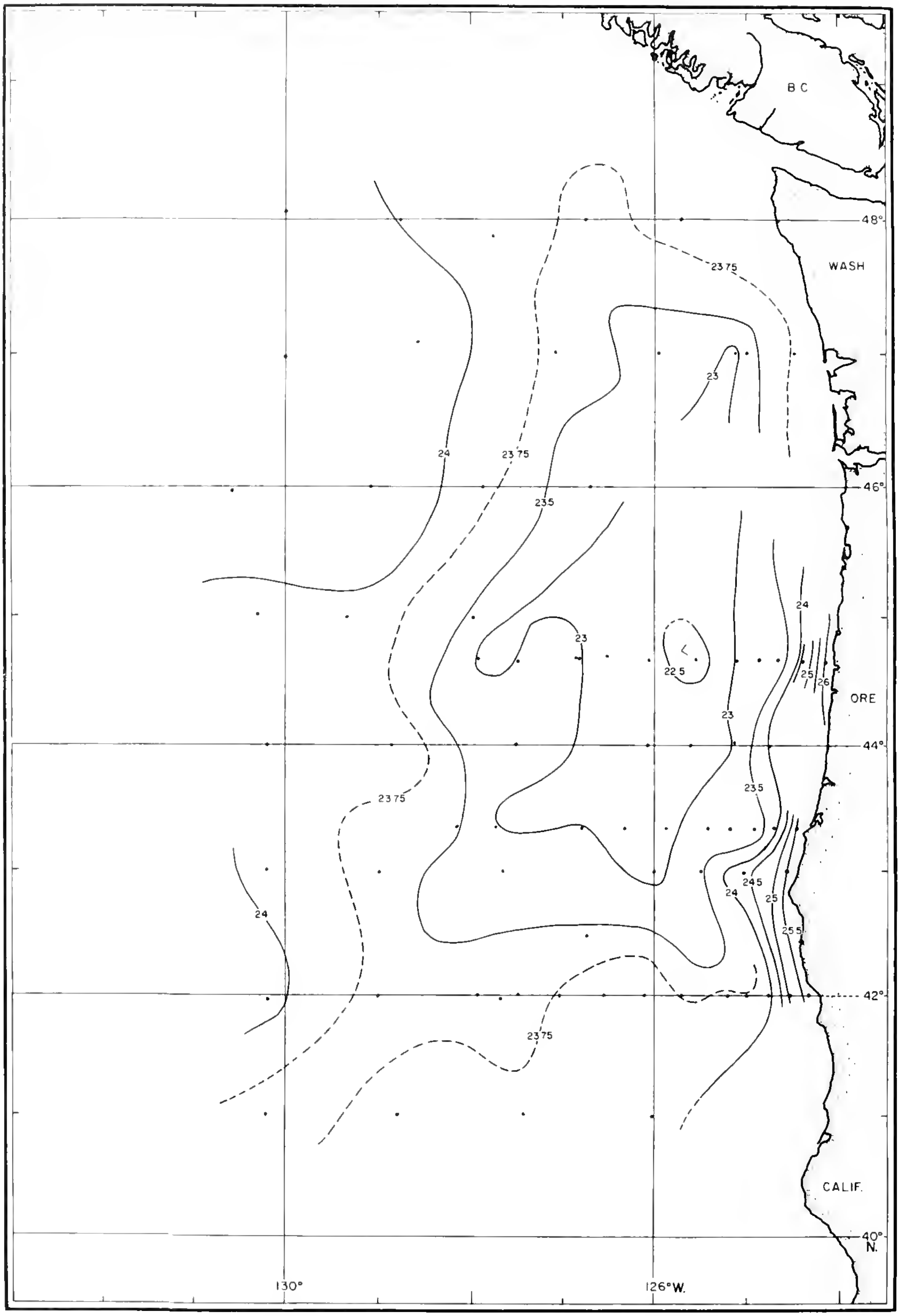

Figure 11.--Horizontal distribution of density at 10 m., July 1963. Contour interval is 0.5 σ_t unit.

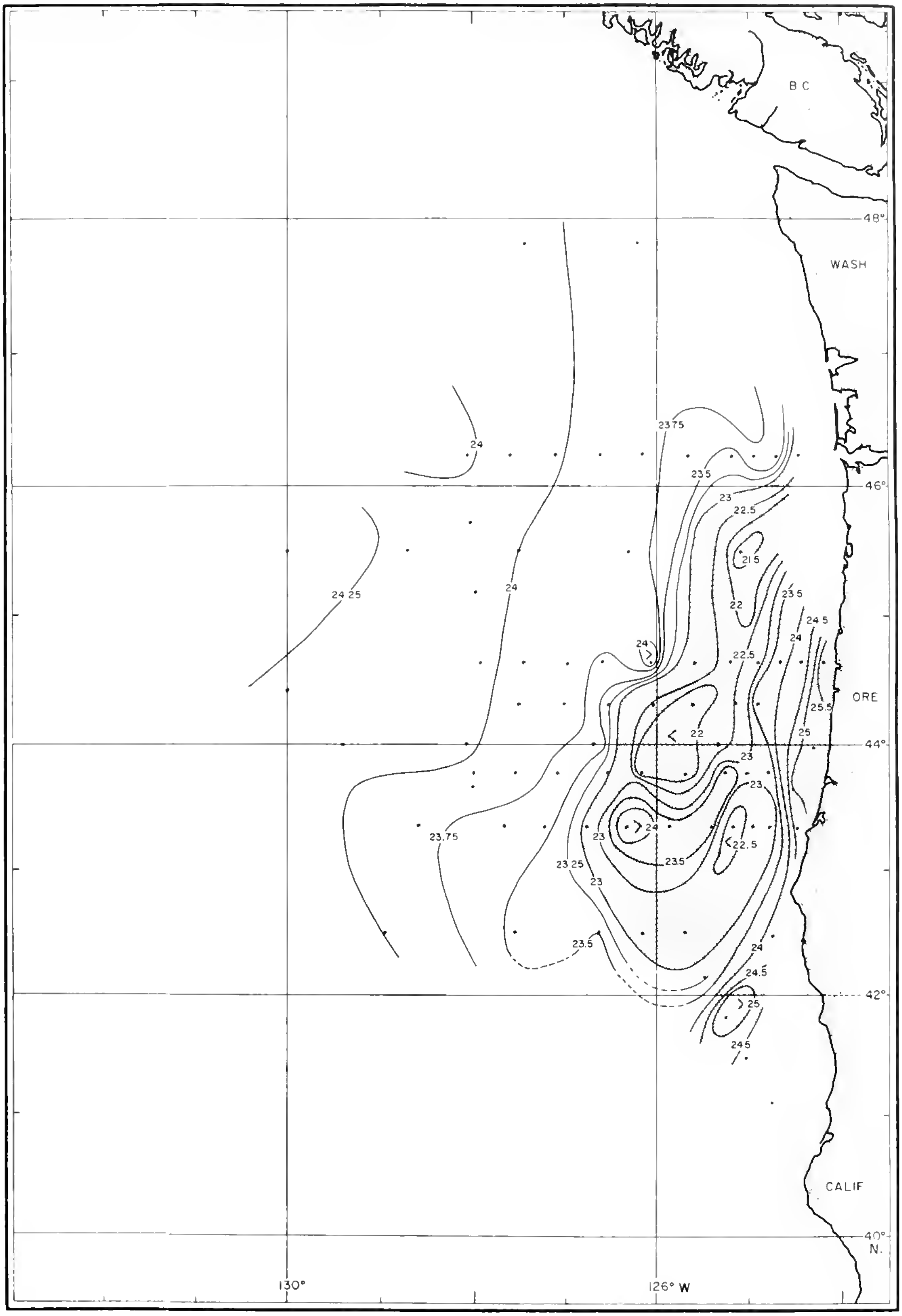

Figure 12.--Horizontal distribution of density at 10 m., July 1964. Contour interval is 0.5 σ_t unit except where shaded.

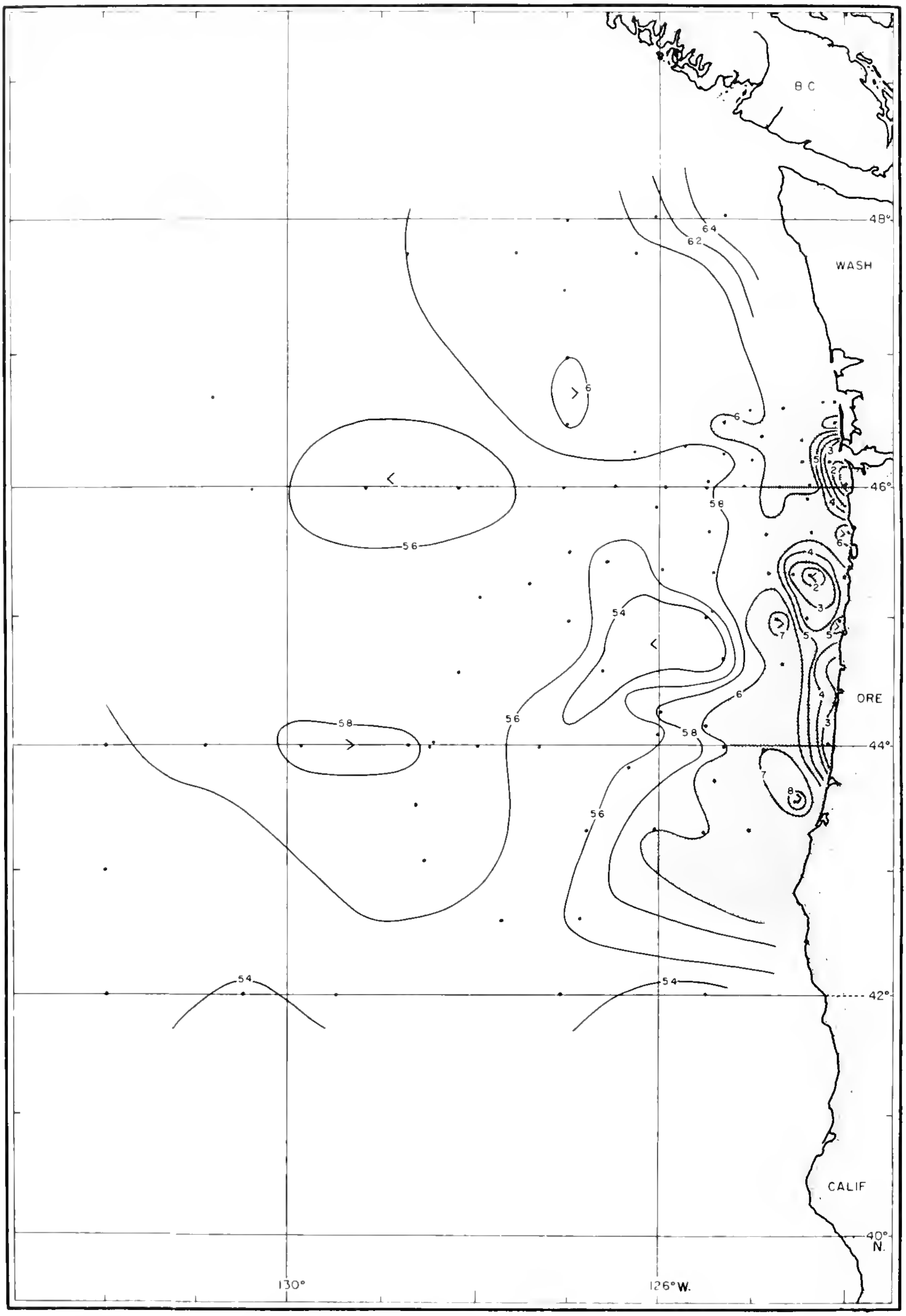

Figure 13.--Horizontal distribution of oxygen concentration at 10 m., July 1961. Contour interval is 0.2 ml./l. except where shaded.

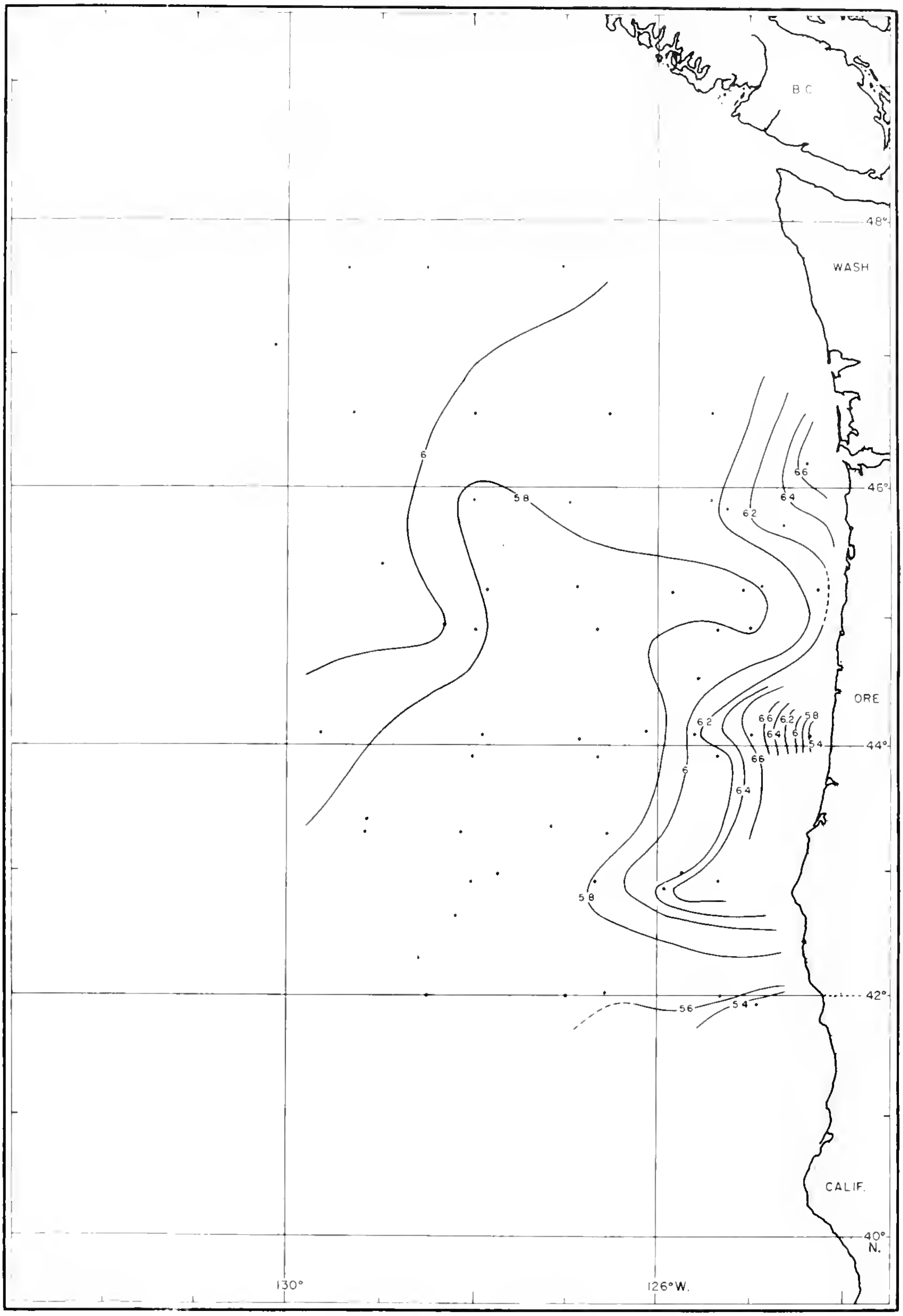

Figure 14.--Horizontal distribution of oxygen concentration at 10 m., July 1962. Contour interval is 0.2 ml./l.

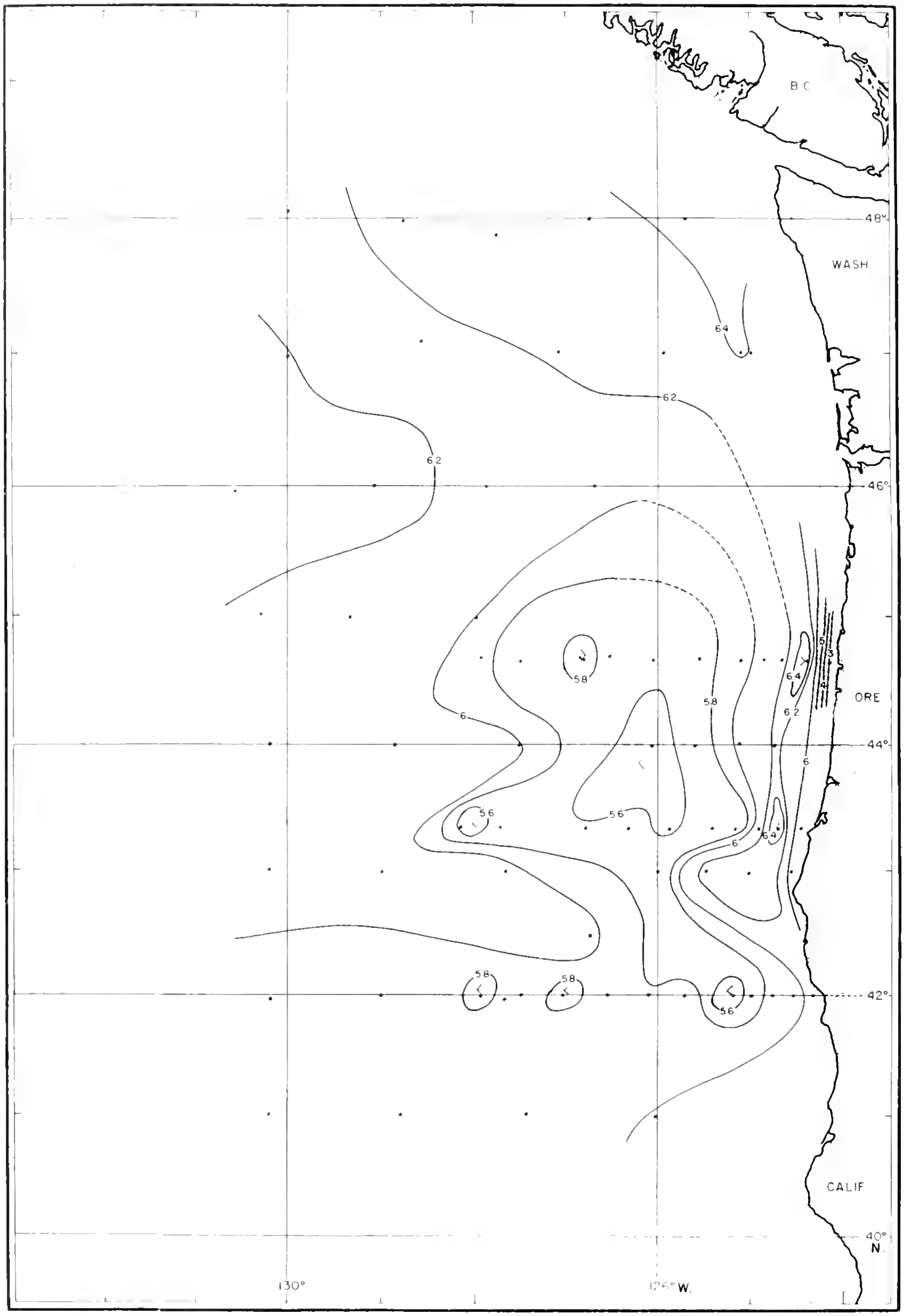

Figure 15.--Horizontal distribution of oxygen concentration at 10 m., July 1963. Contour interval is 0.2 ml./l. except where shaded.

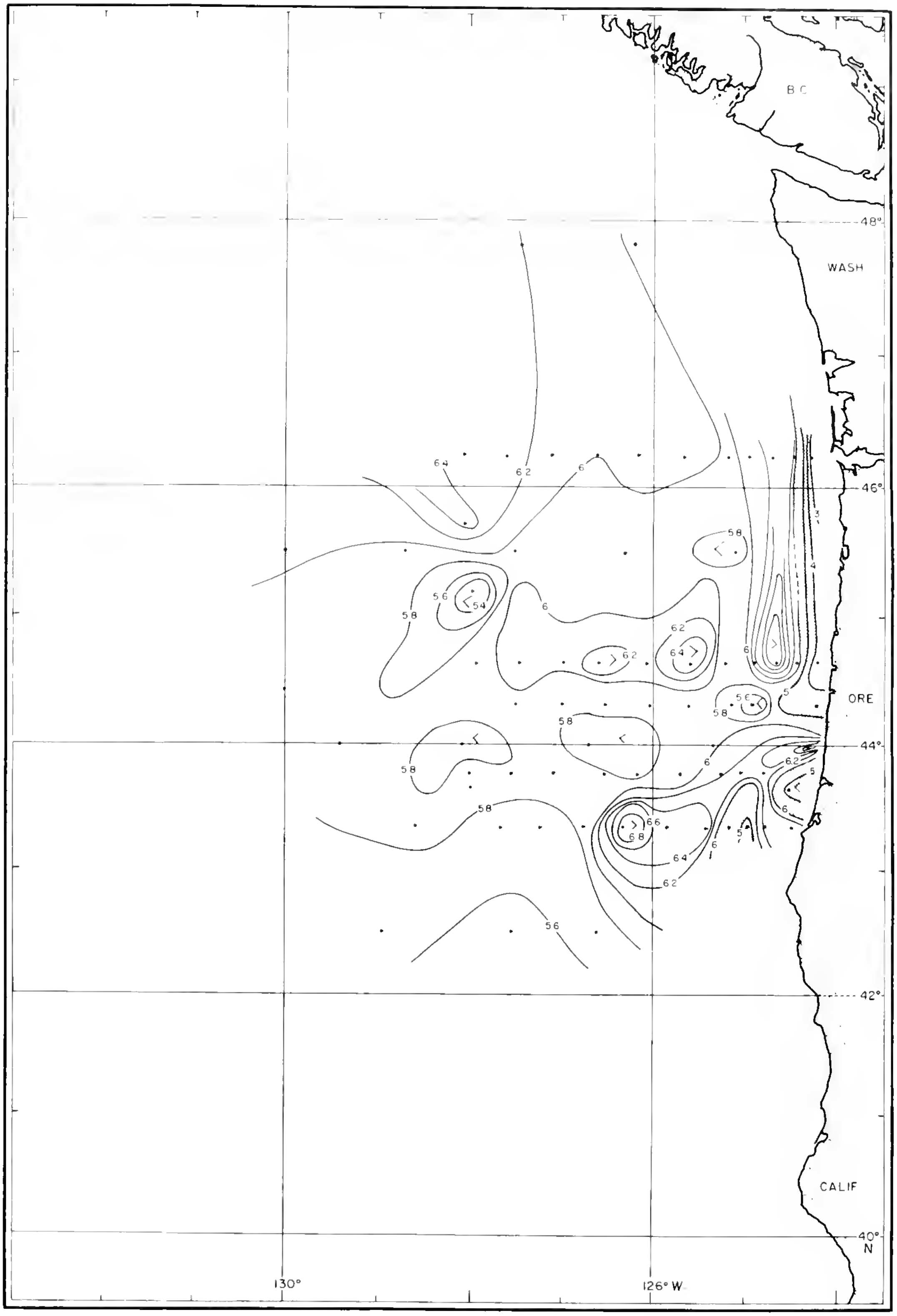

Figure 16.--Horizontal distribution of oxygen concentration at 10 m., July 1964. Contour interval is 0.2 ml./l. except where shaded.

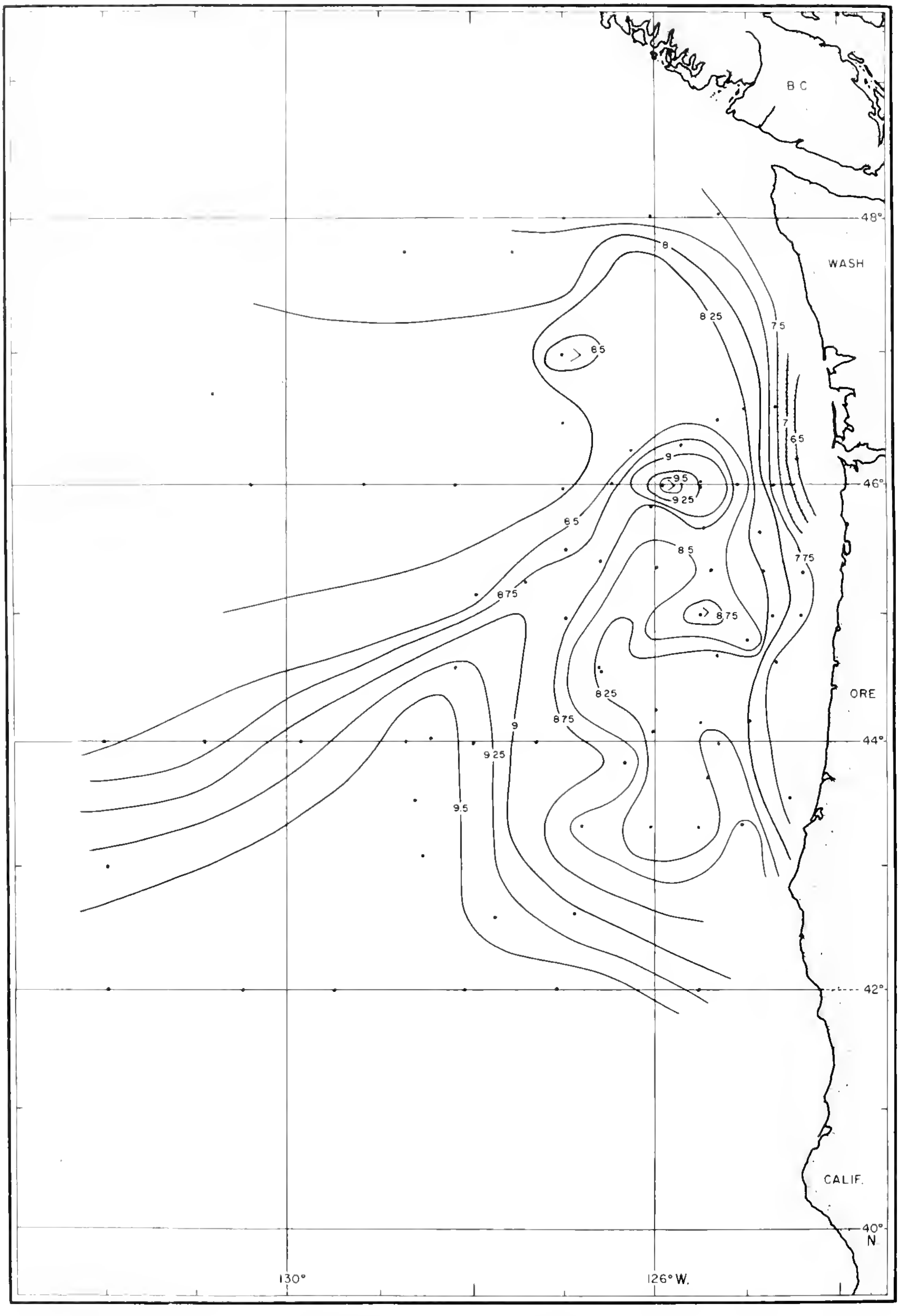

Figure 17.--Horizontal distribution of temperature at 100 m., July 1961. Contour interval is 0.25° C. except where shaded.

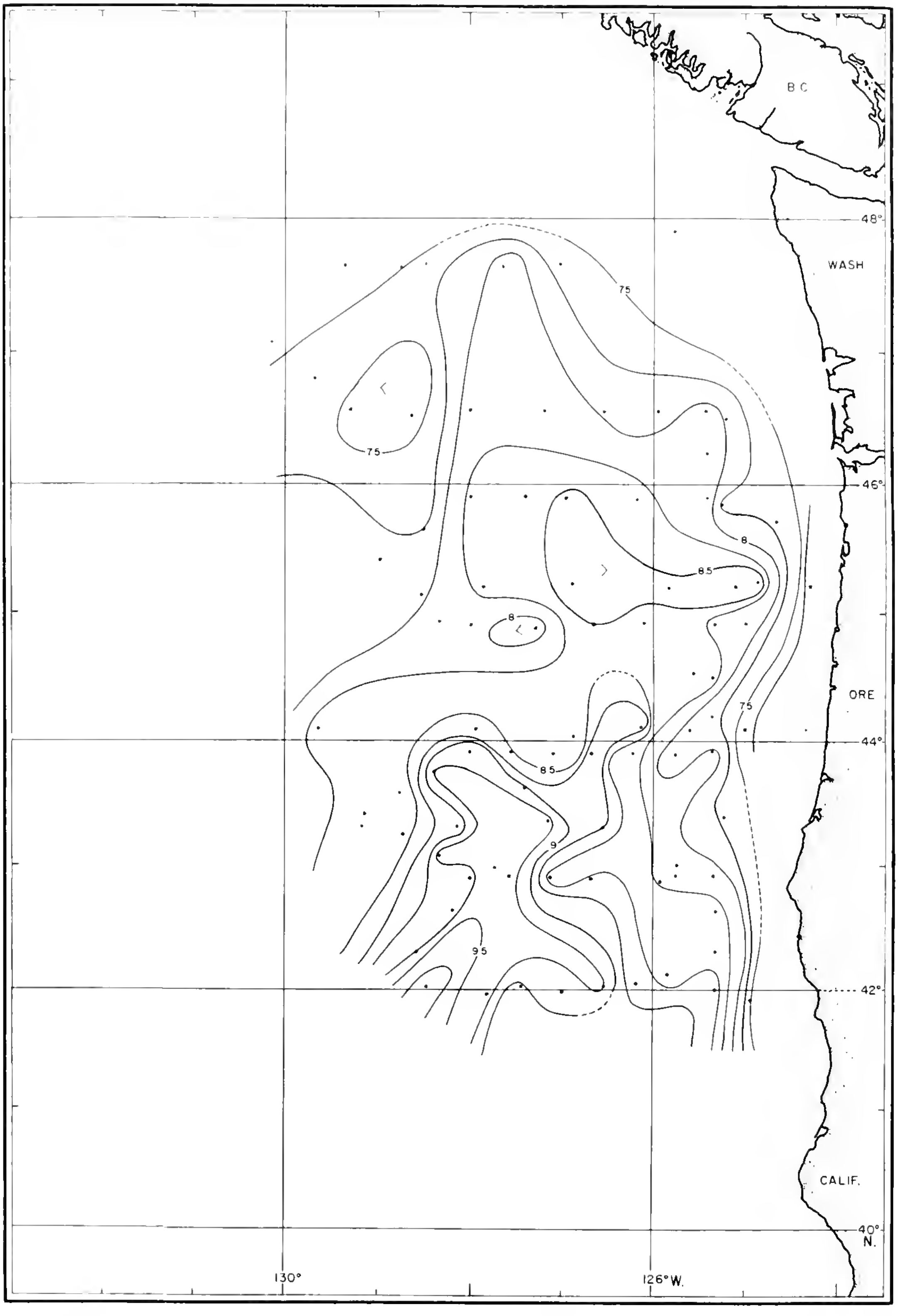

Figure 18.--Horizontal distribution of temperature at 100 m., July 1962. Contour interval is 0.25° C.

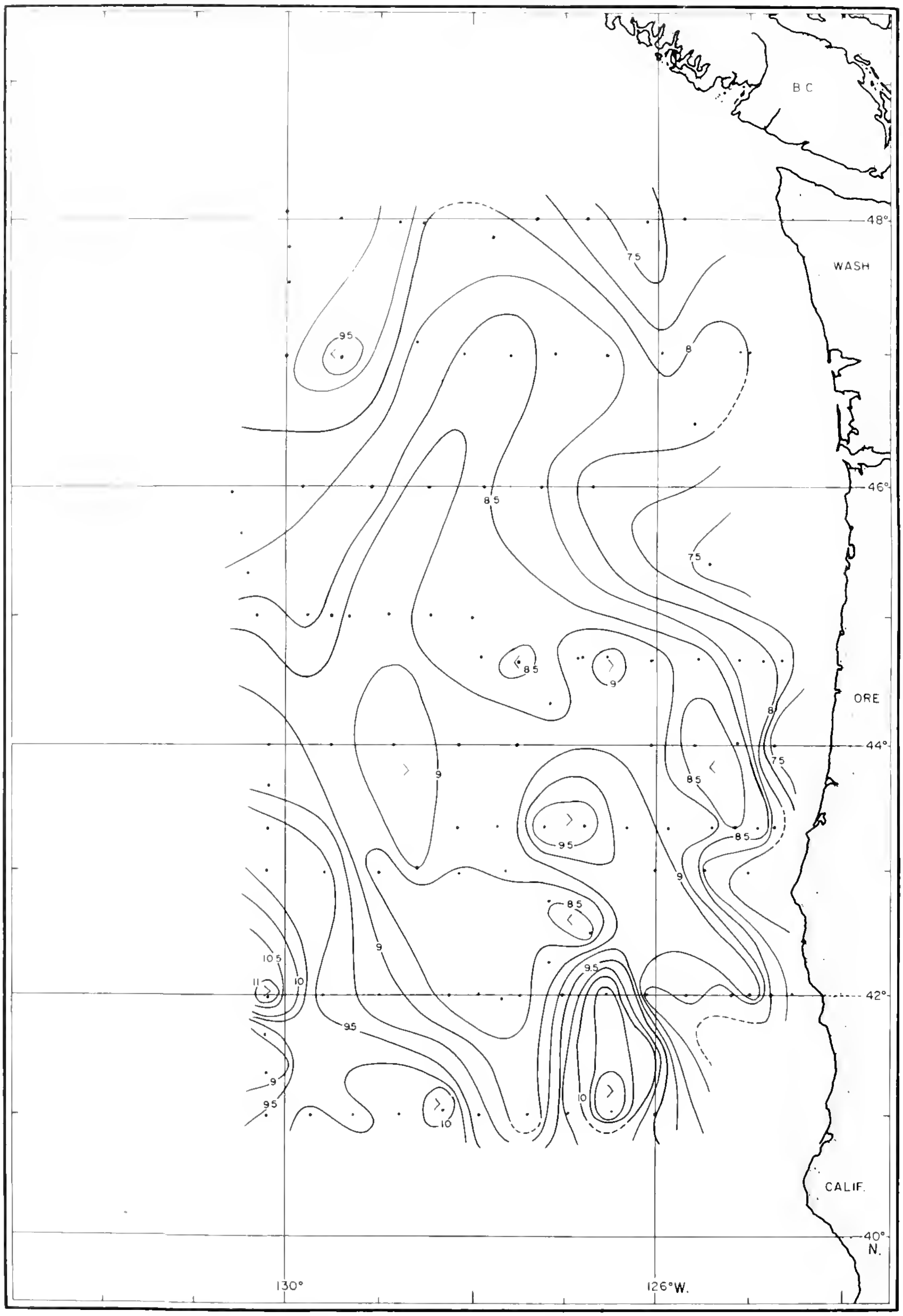

Figure 19.--Horizontal distribution of temperature at 100 m., July 1963. Contour interval is 0.25° C.

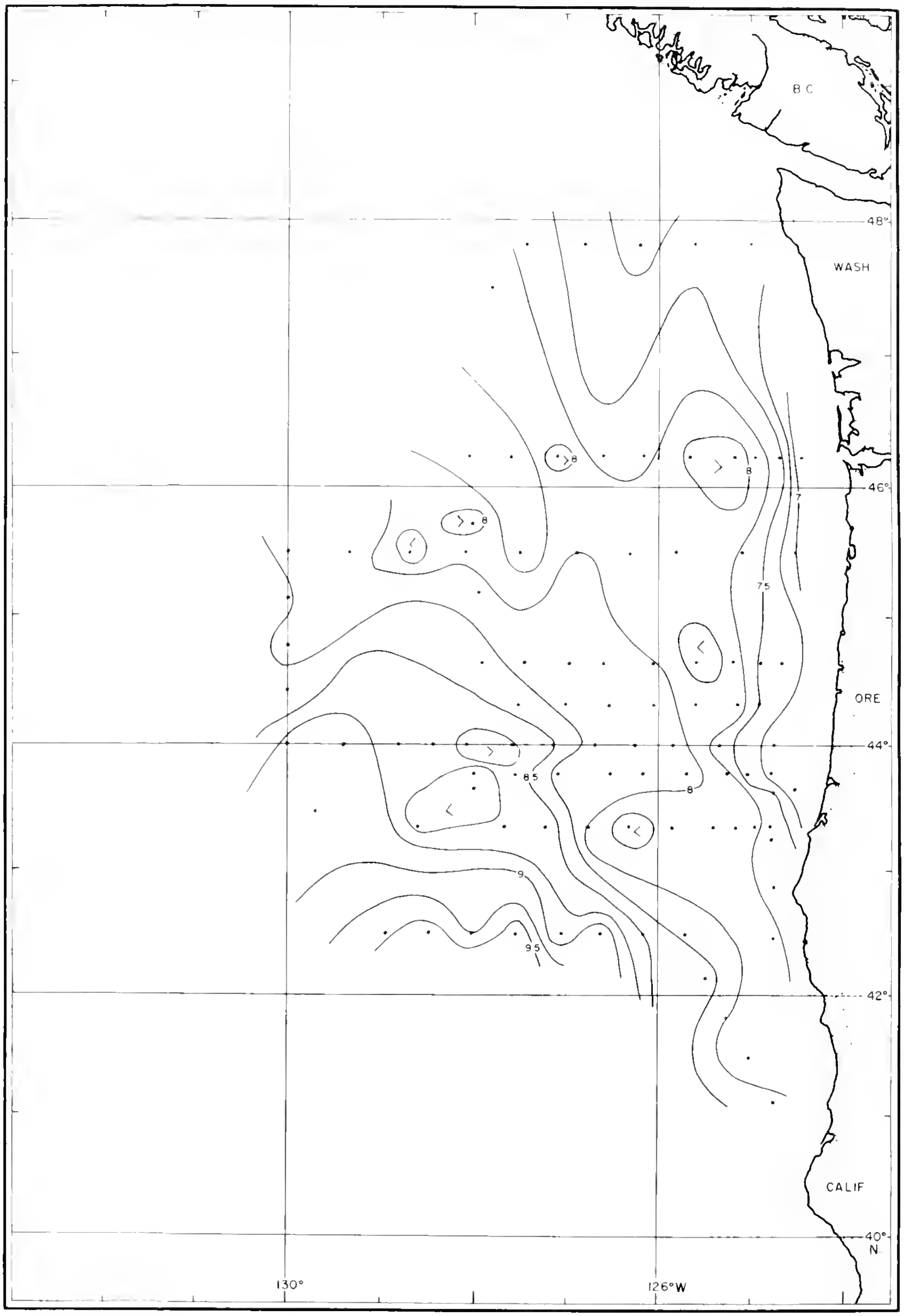

Figure 20.--Horizontal distribution of temperature at 100 m., July 1964. Contour interval is 0.25° C.

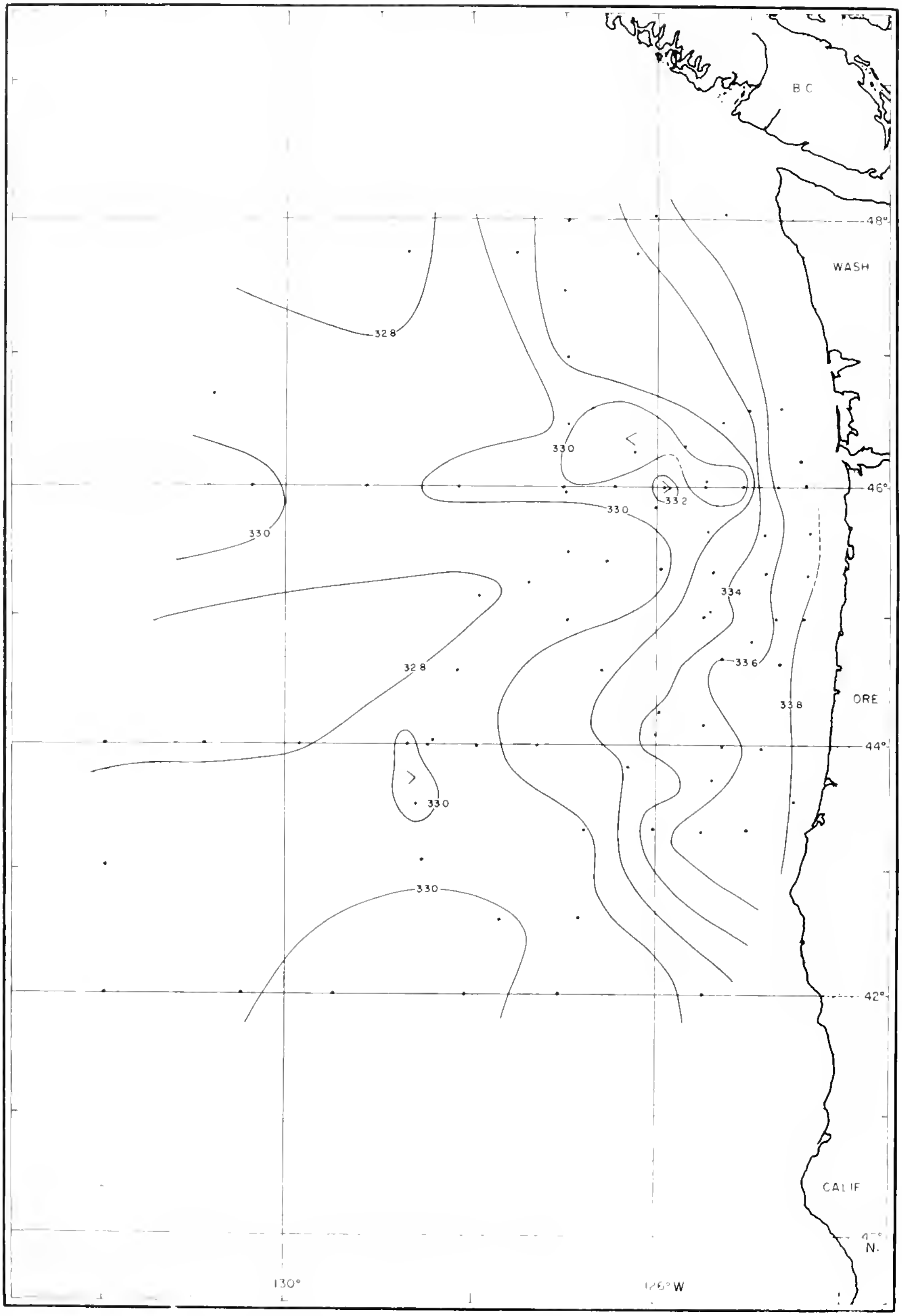

Figure 21.--Horizontal distribution of salinity at 100 m., July 1961. Contour interval is 0.2 p.p.t.

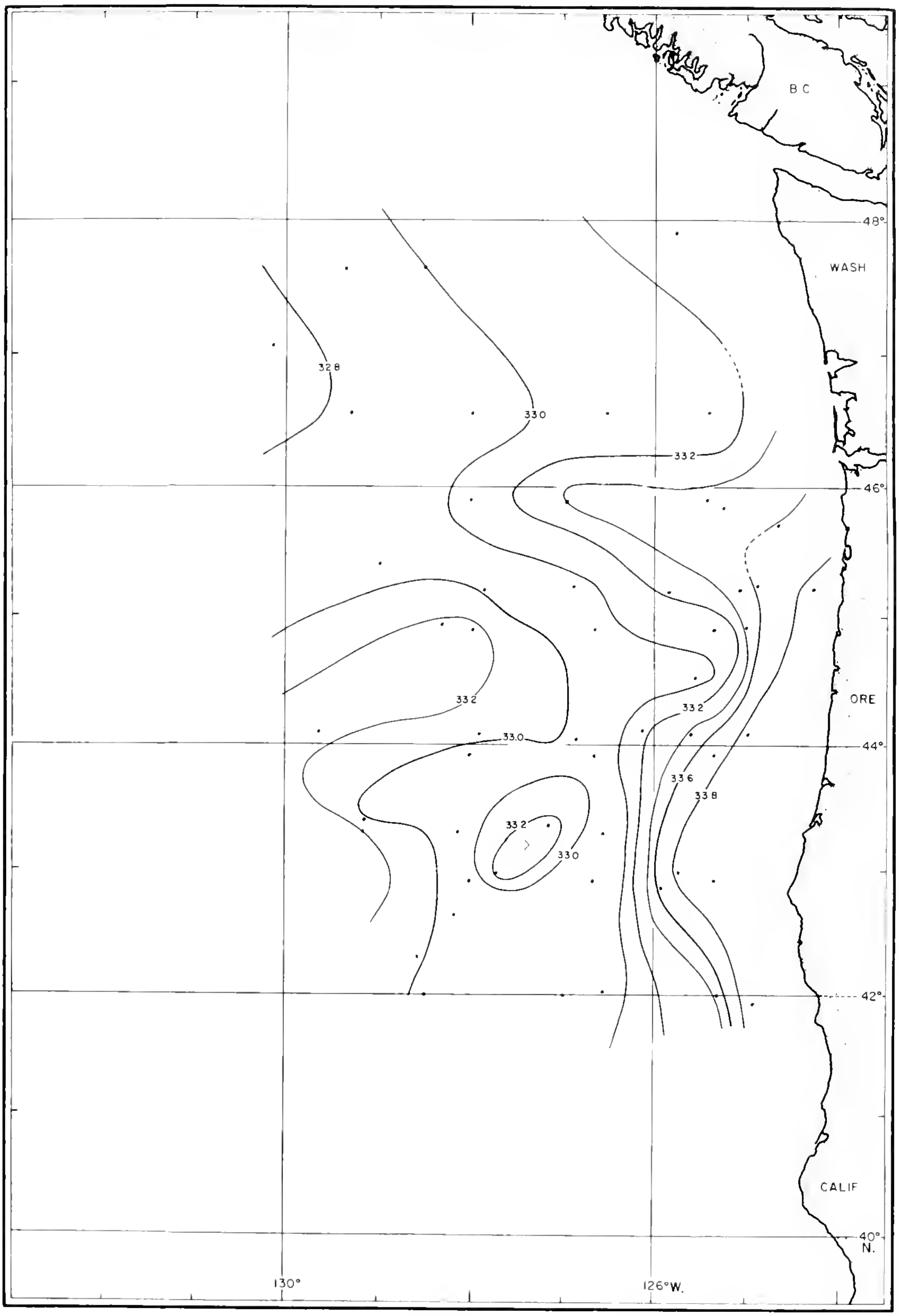

Figure 22.--Horizontal distribution of salinity at 100 m., July 1962. Contour interval is 0.2 p.p.t.

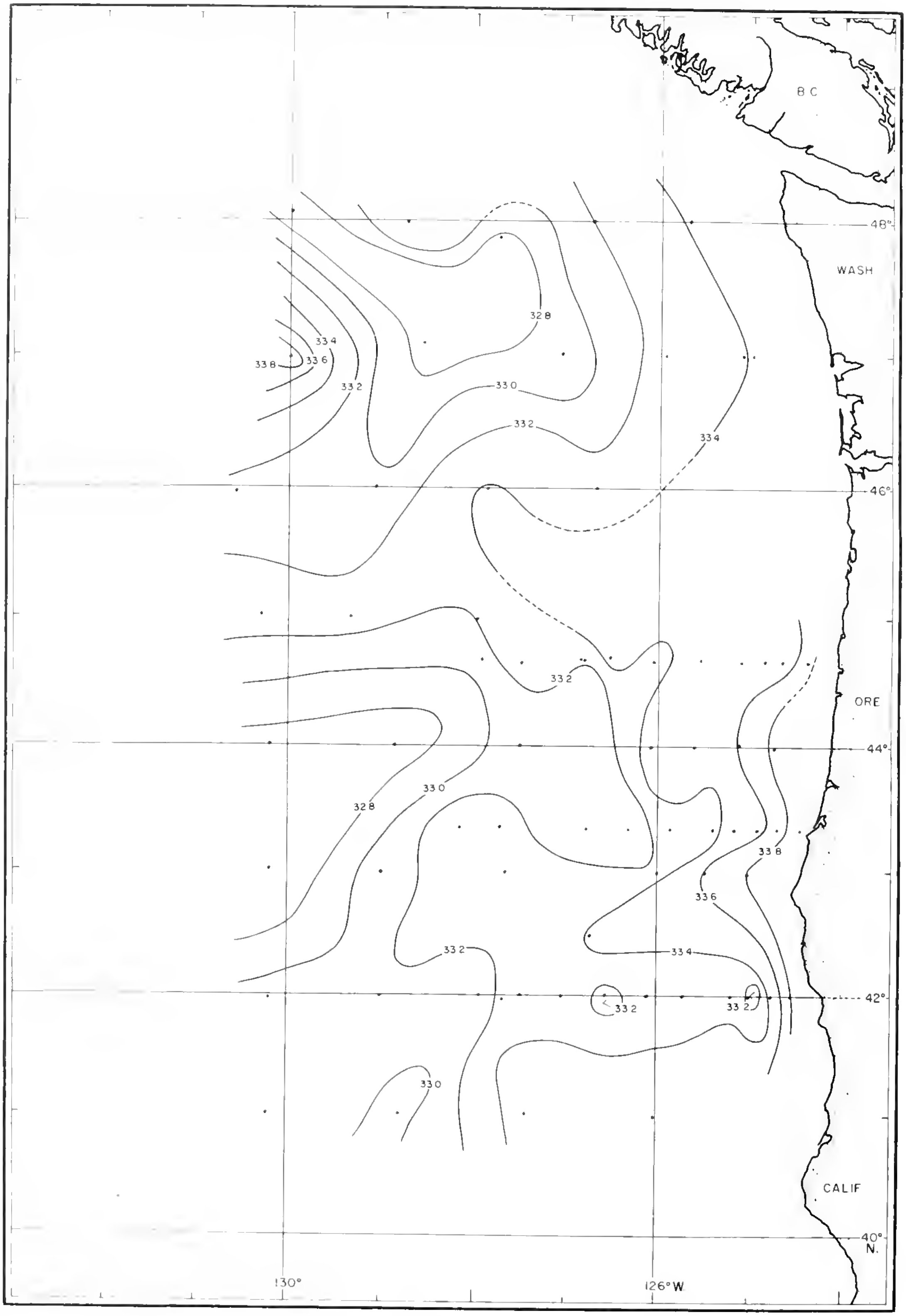

Figure 23.--Horizontal distribution of salinity at 100 m., July 1963. Contour interval is 0.2 p.p.t.

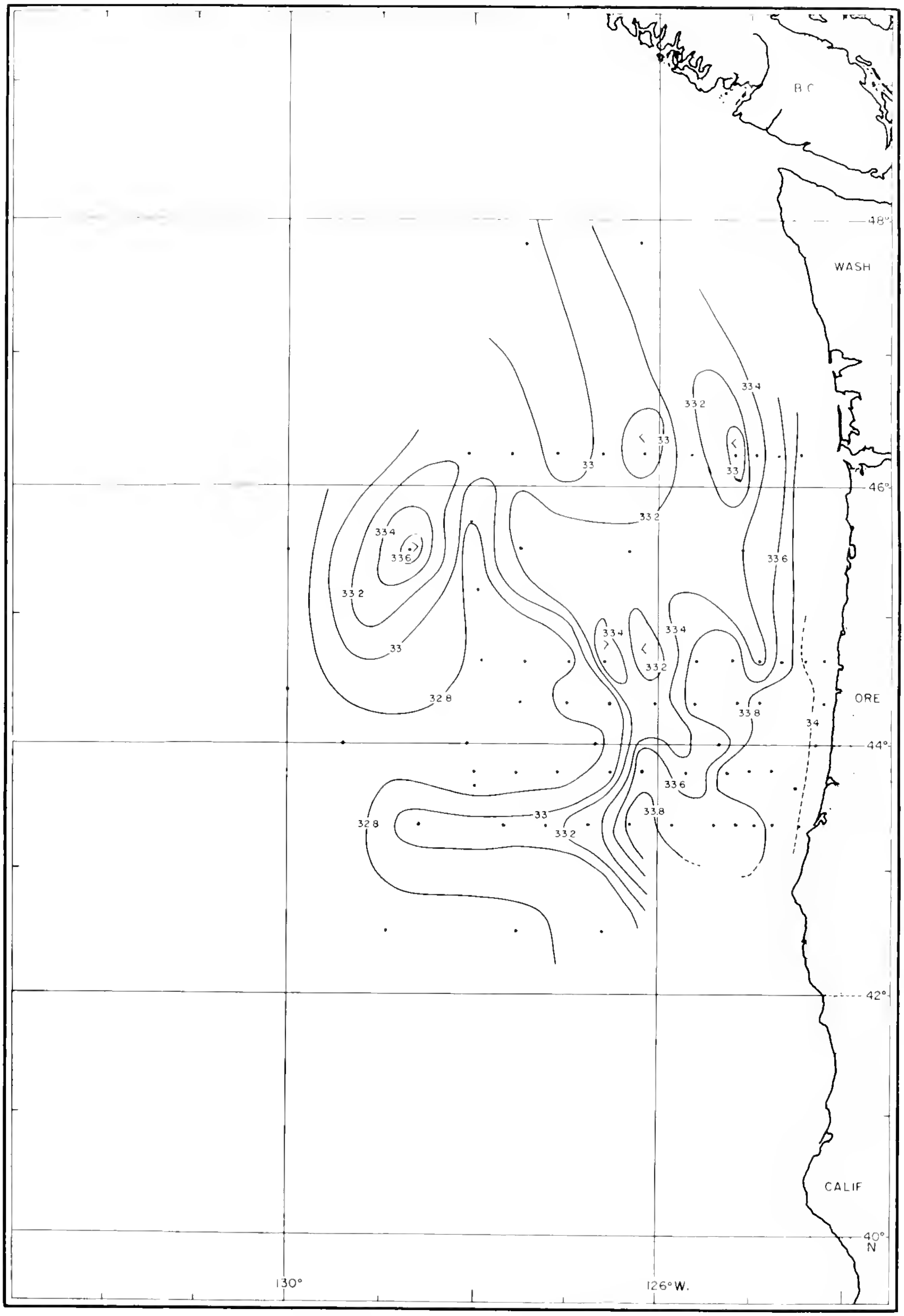

Figure 24.--Horizontal distribution of salinity at 100 m., July 1964. Contour interval is 0.2 p.p.t.

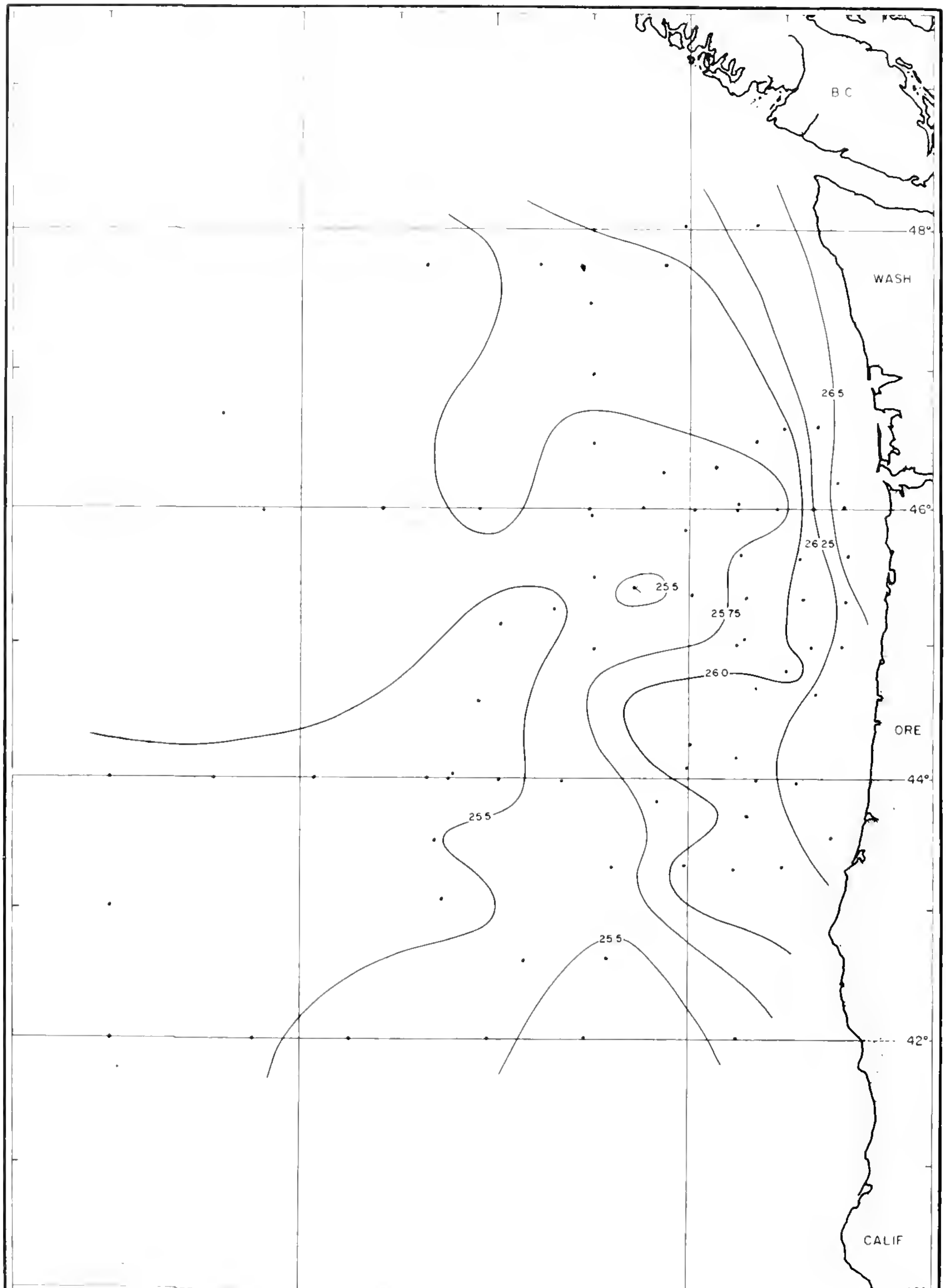

Figure 25.--Horizontal distribution of density at 100 m., July 1961. Contour interval is 0.25 σ_t unit.

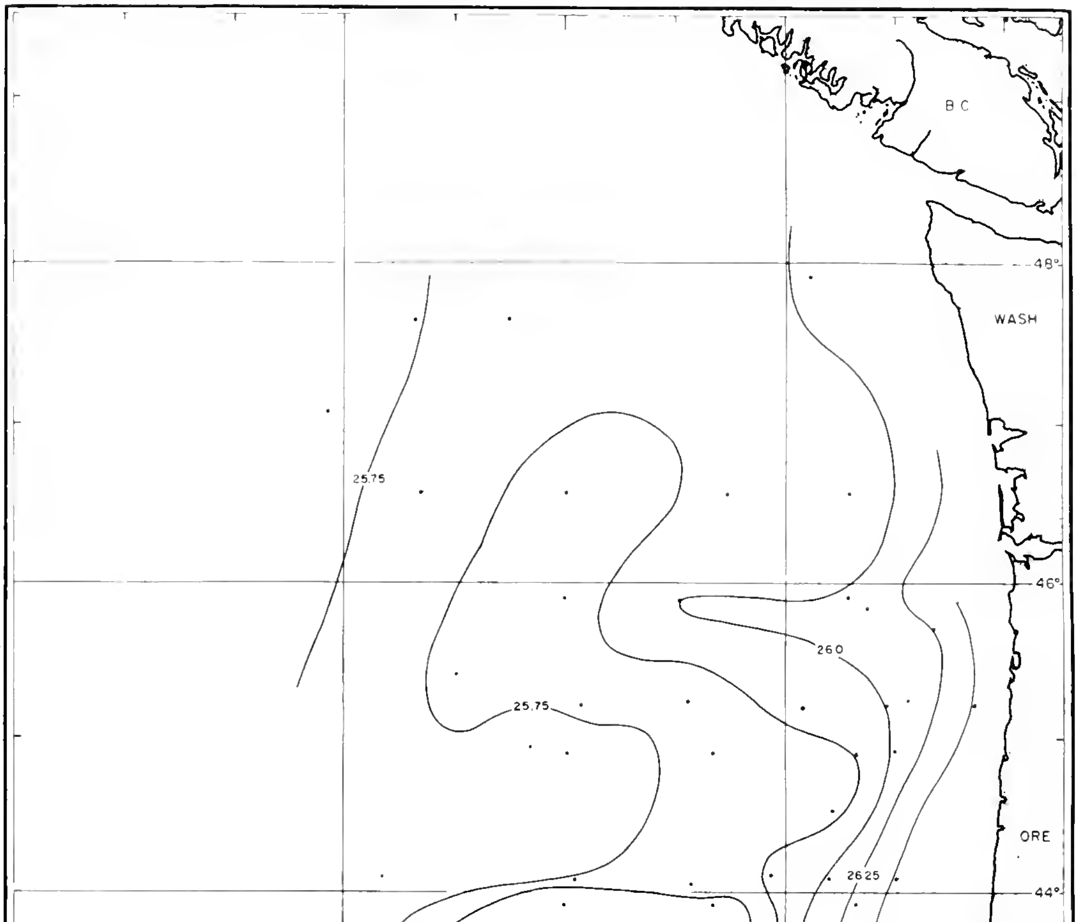

Figure 26.--Horizontal distribution of density at 100 m., July 1962. Contour interval is 0.25 σ_t unit.

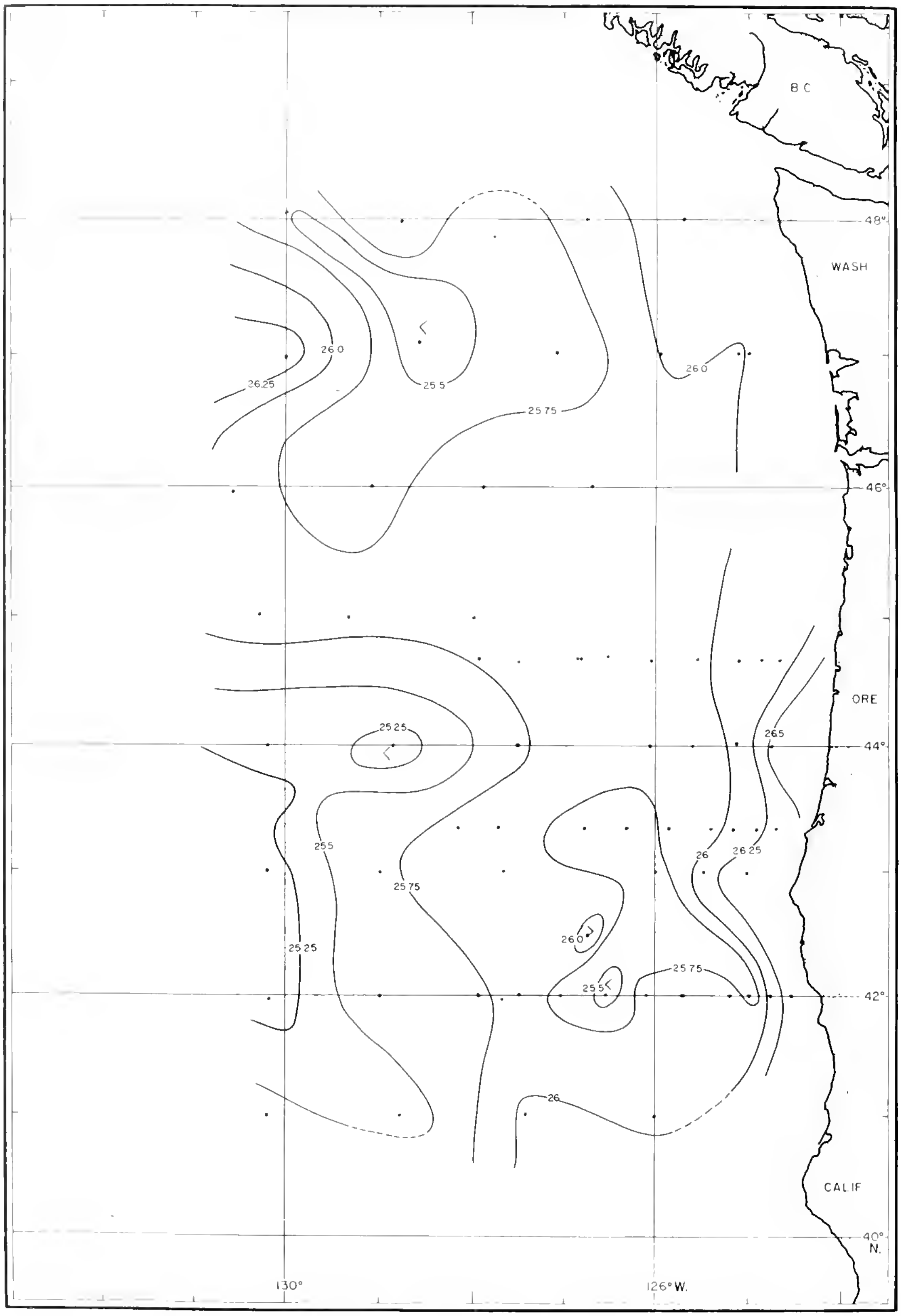

Figure 27.--Horizontal distribution of density at 100 m., July 1963. Contour interval is 0.25 σ_t unit.

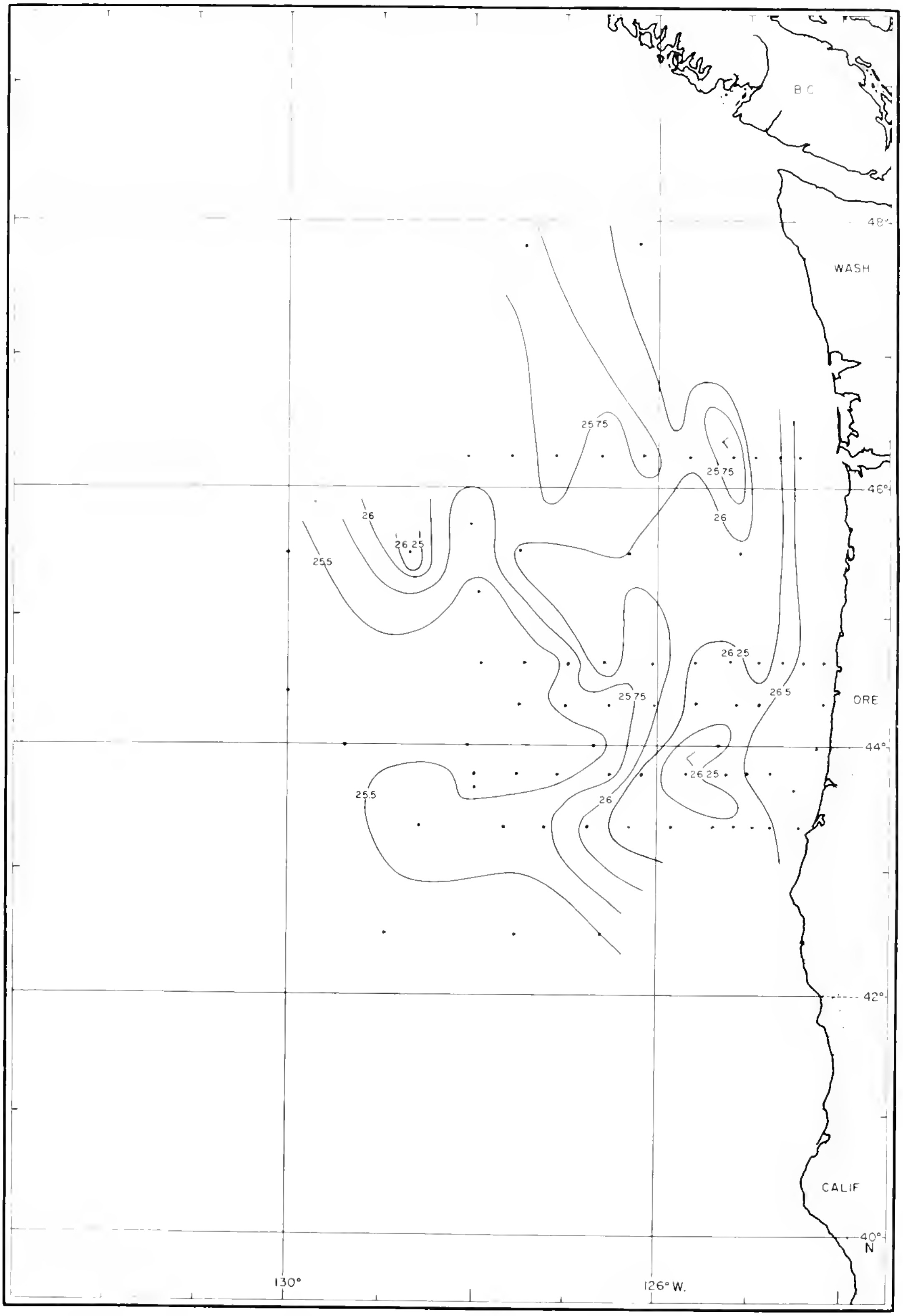

Figure 28.--Horizontal distribution of density at 100 m., July 1964. Contour interval is 0.25 σ_t unit.

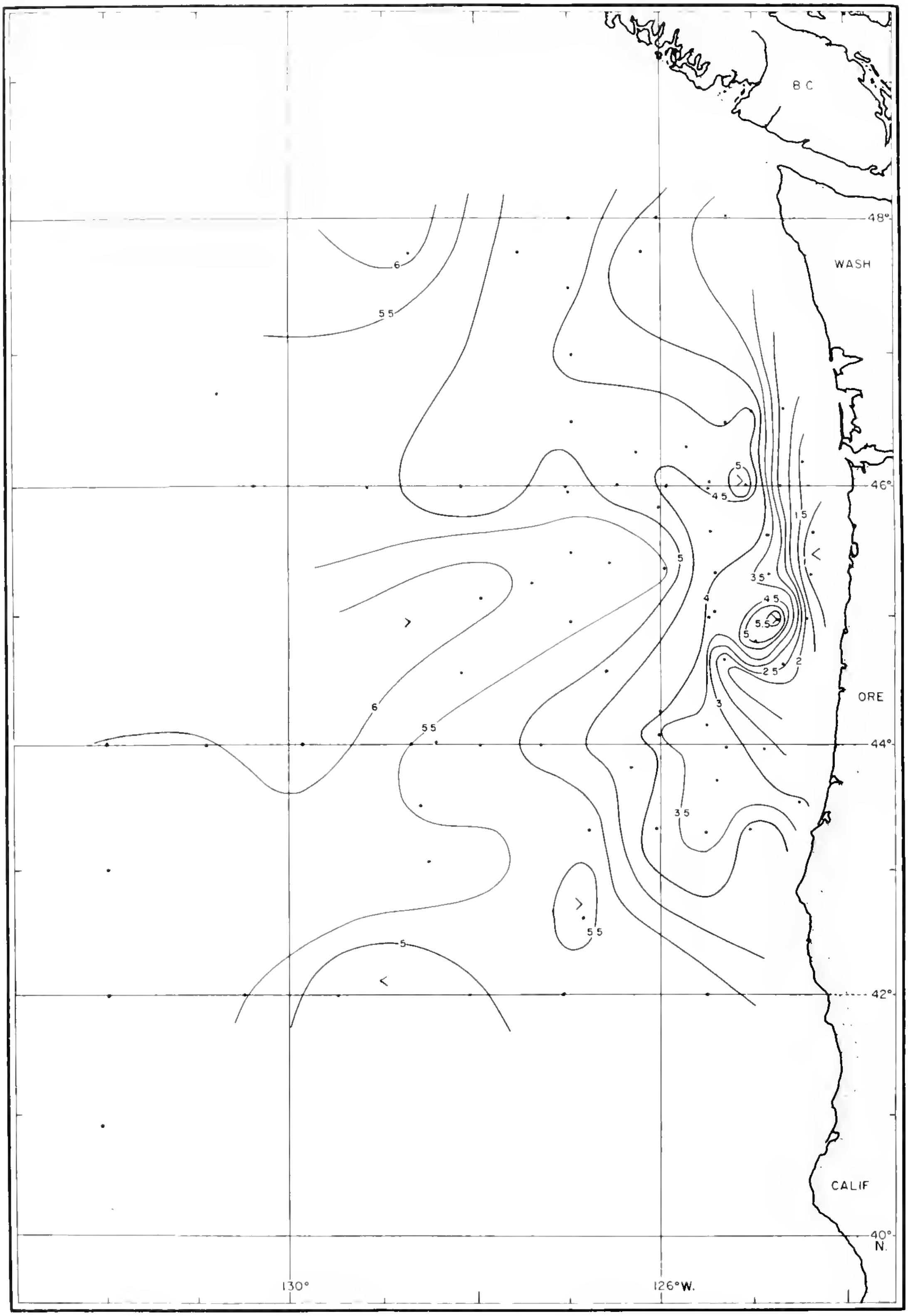

Figure 29.--Horizontal distribution of oxygen concentration at 100 m., July 1961. Contour interval is 0.5 ml./l.

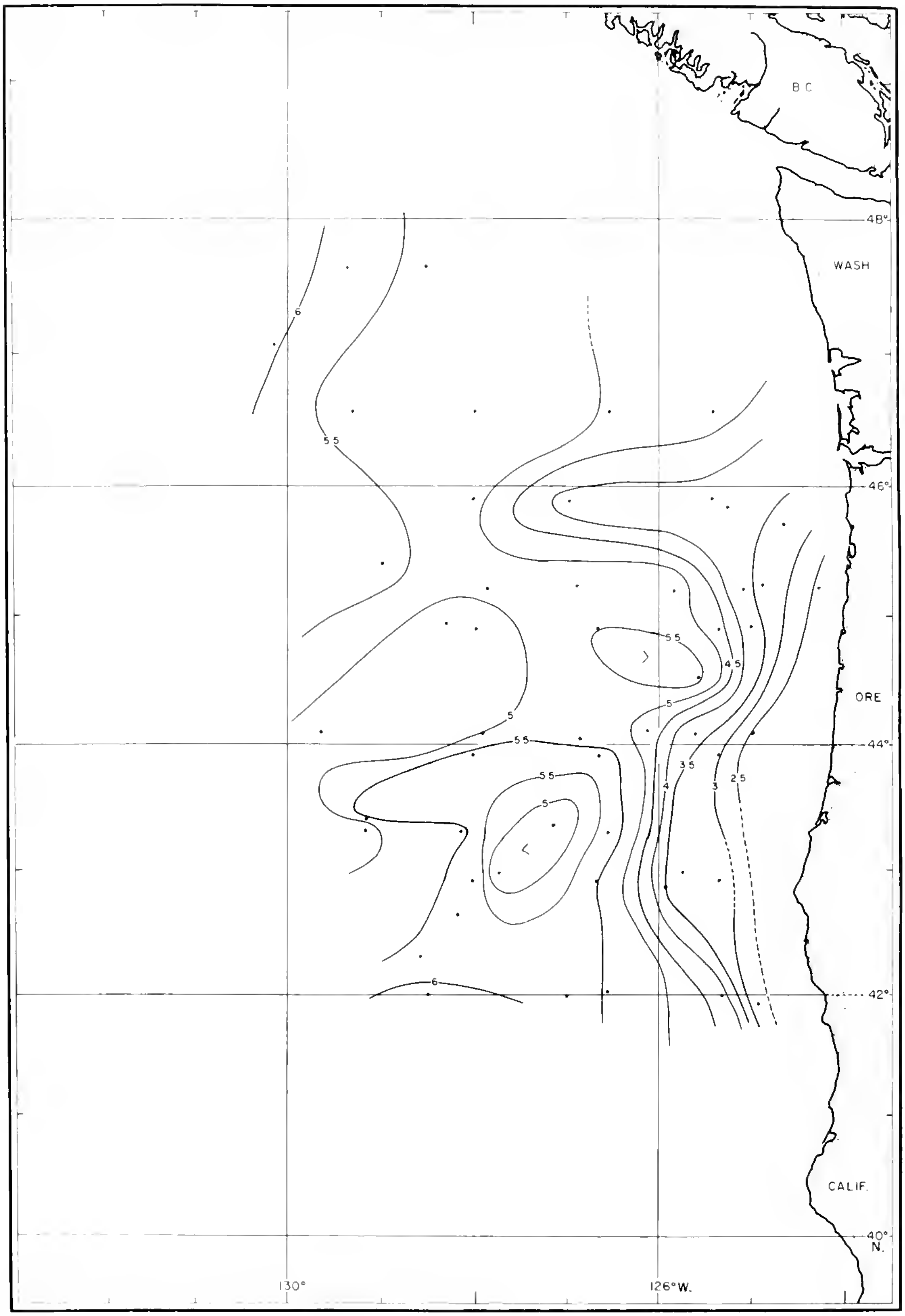

Figure 30.--Horizontal distribution of oxygen concentration at 100 m., July 1962. Contour interval is 0.5 ml./ l.

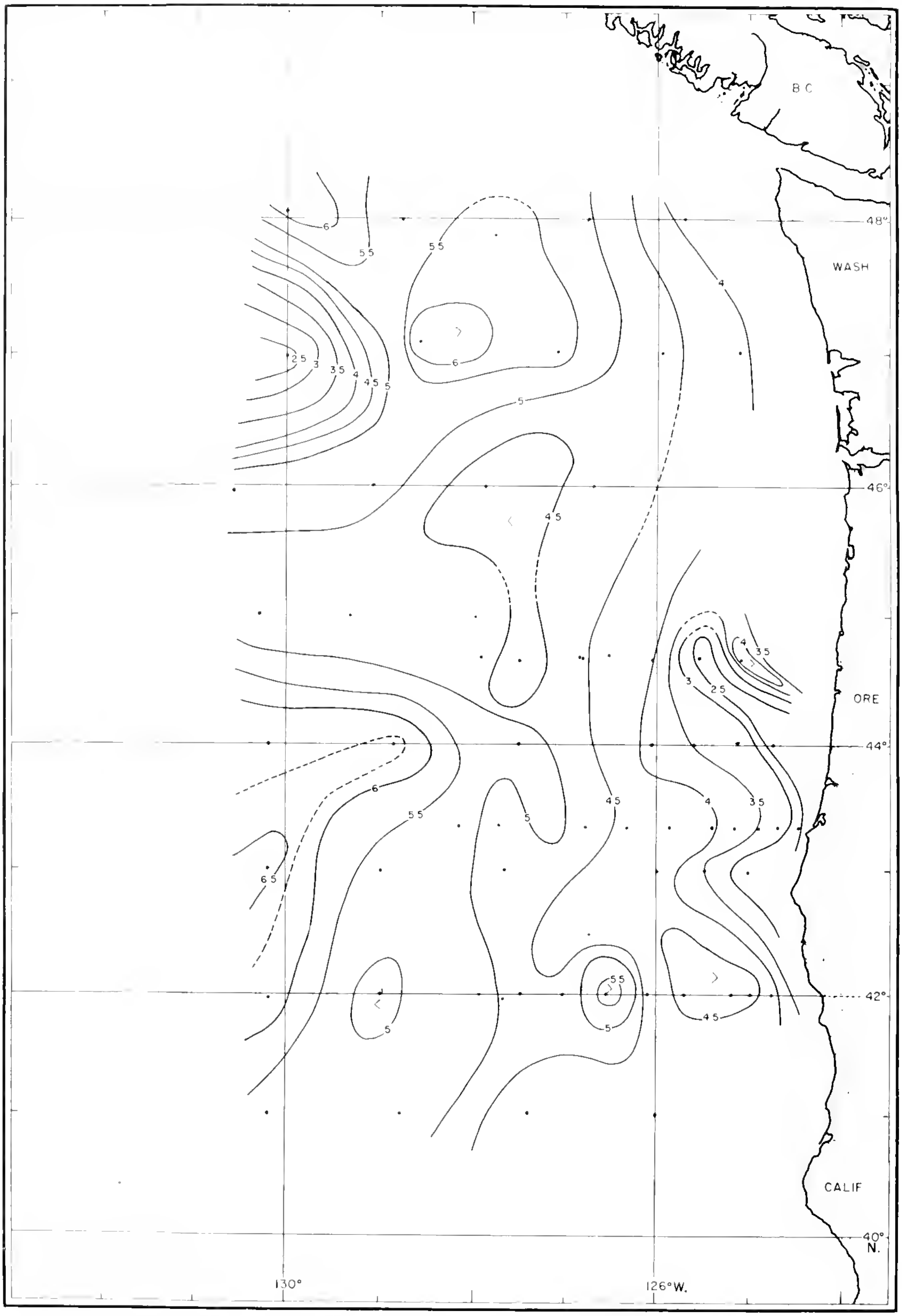

Figure 31.--Horizontal distribution of oxygen concentration at 100 m., July 1963. Contour interval is 0.5 ml./l.

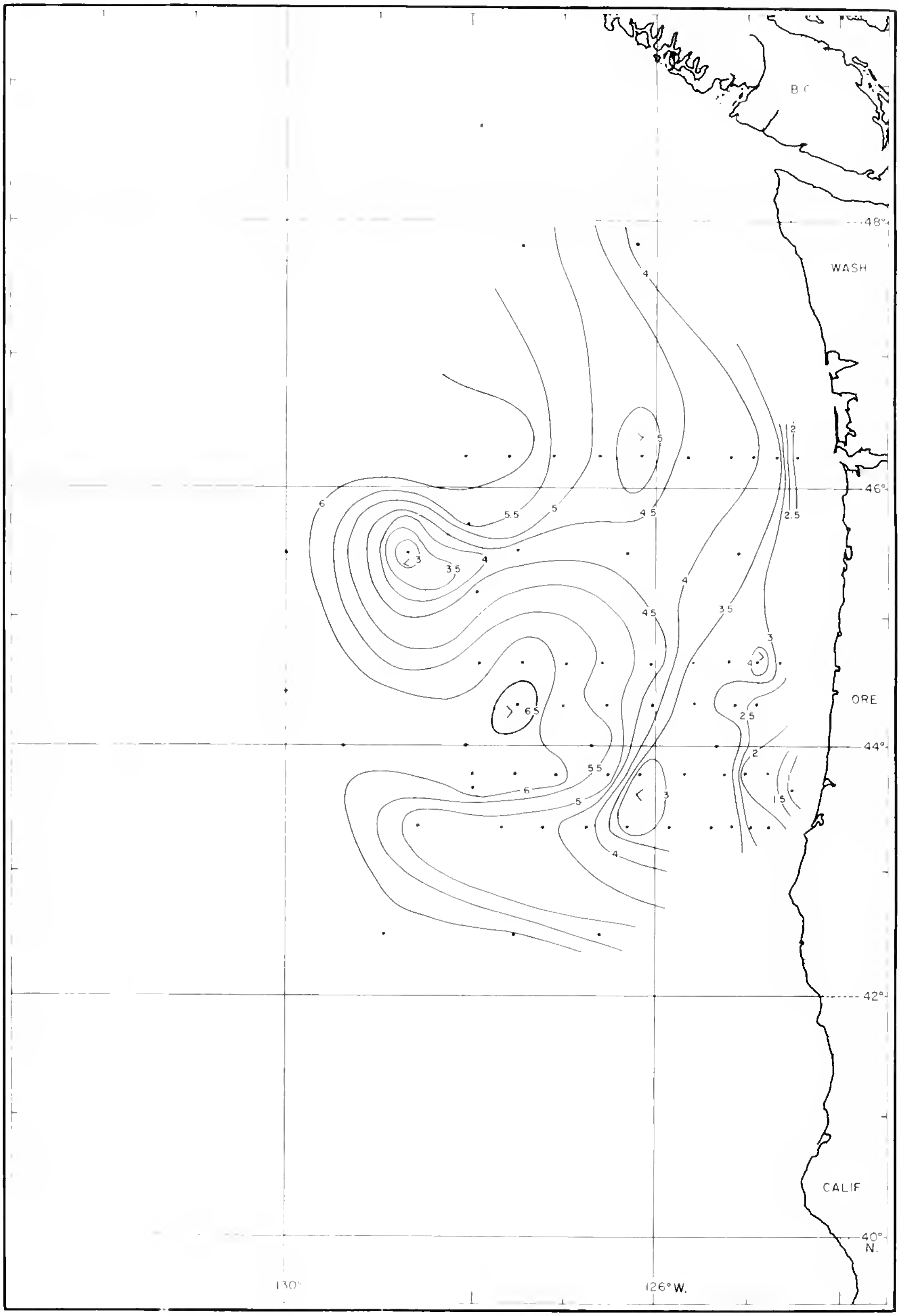

Figure 32.--Horizontal distribution of oxygen concentration at 100 m., July 1964. Contour interval is 0.5 ml./l.

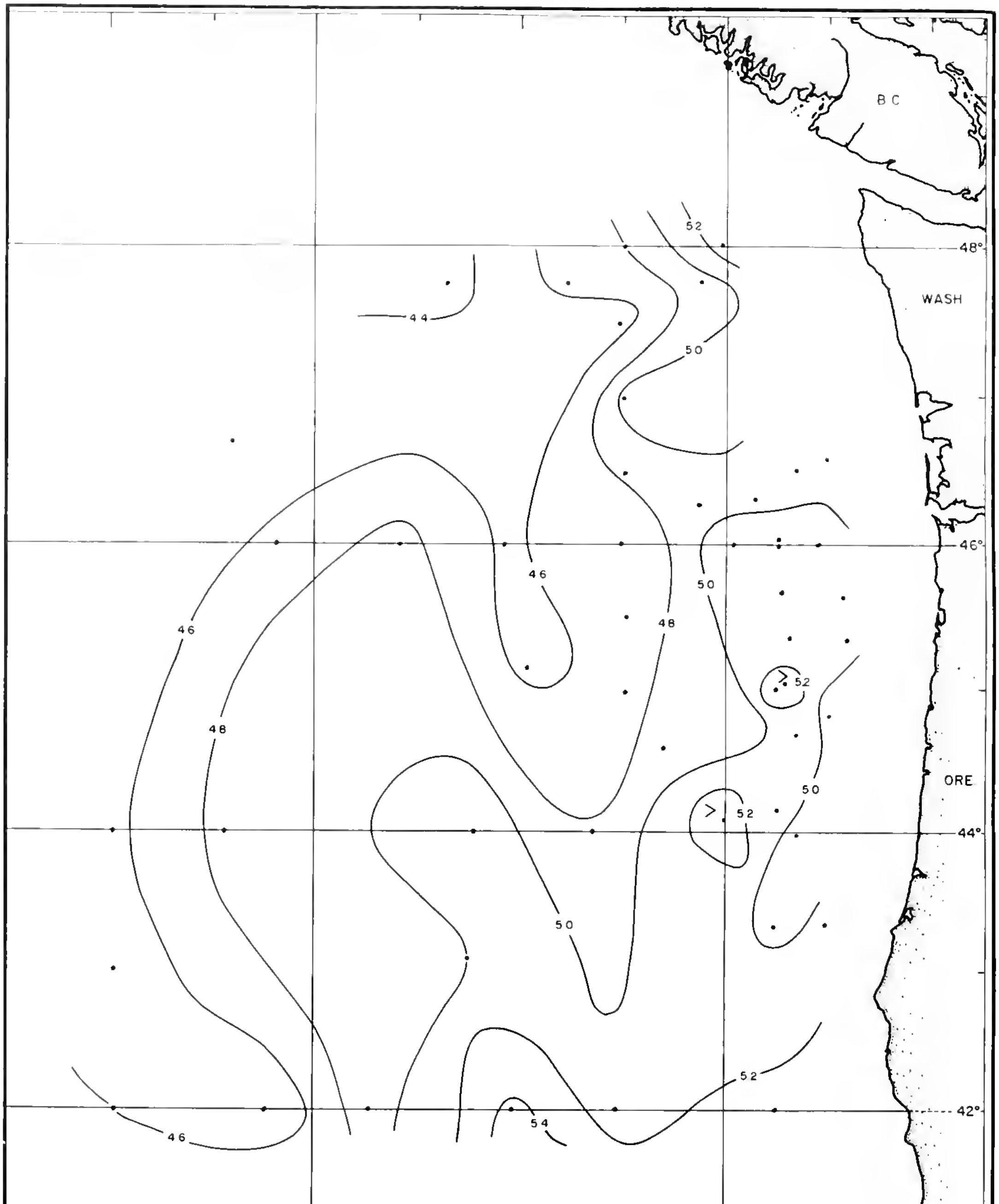

Figure 33.--Horizontal distribution of temperature at 500 m., July 1961. Contour interval is 0.2° C.

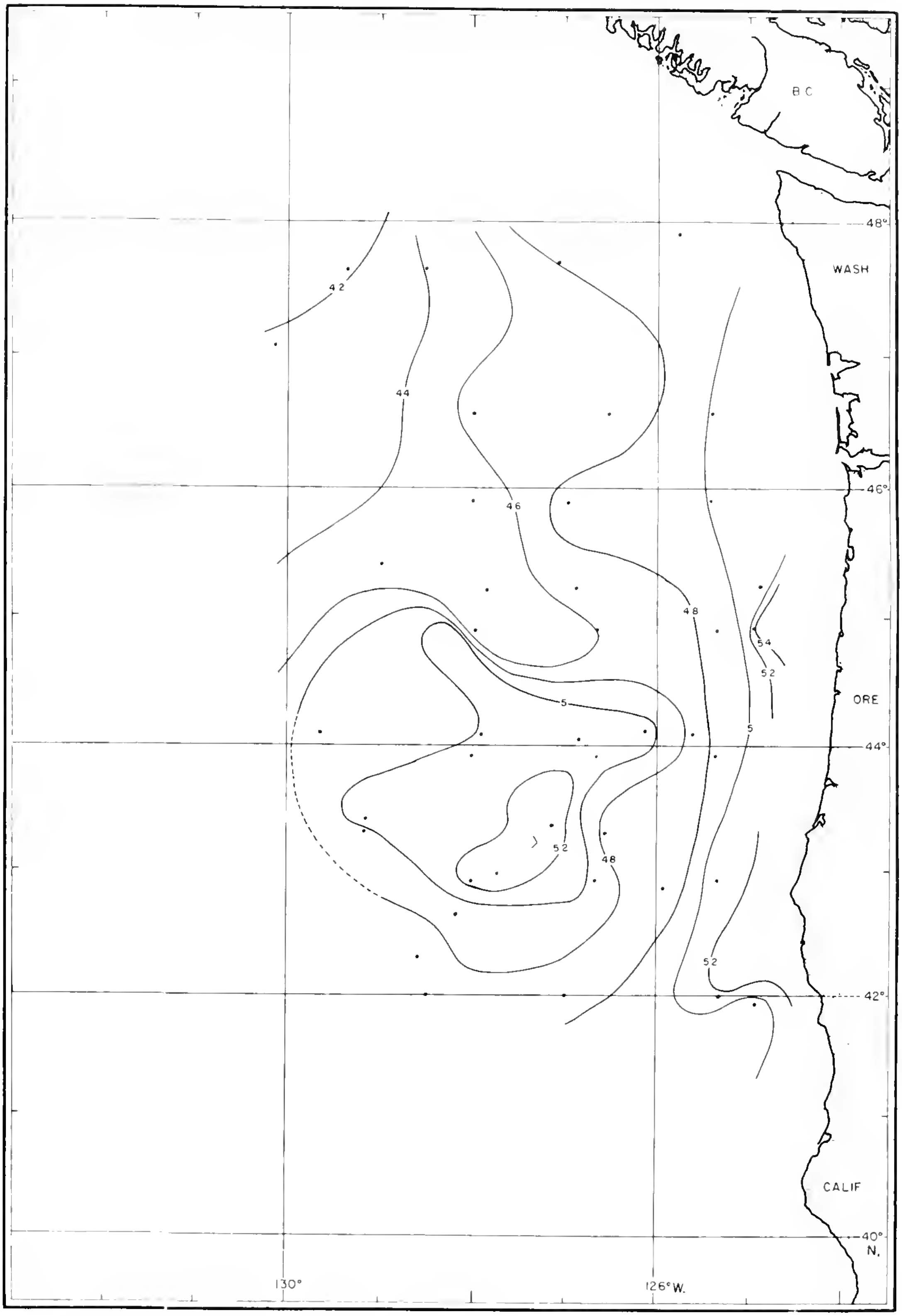

Figure 34.--Horizontal distribution of temperature at 500 m., July 1962. Contour interval is 0.2° C.

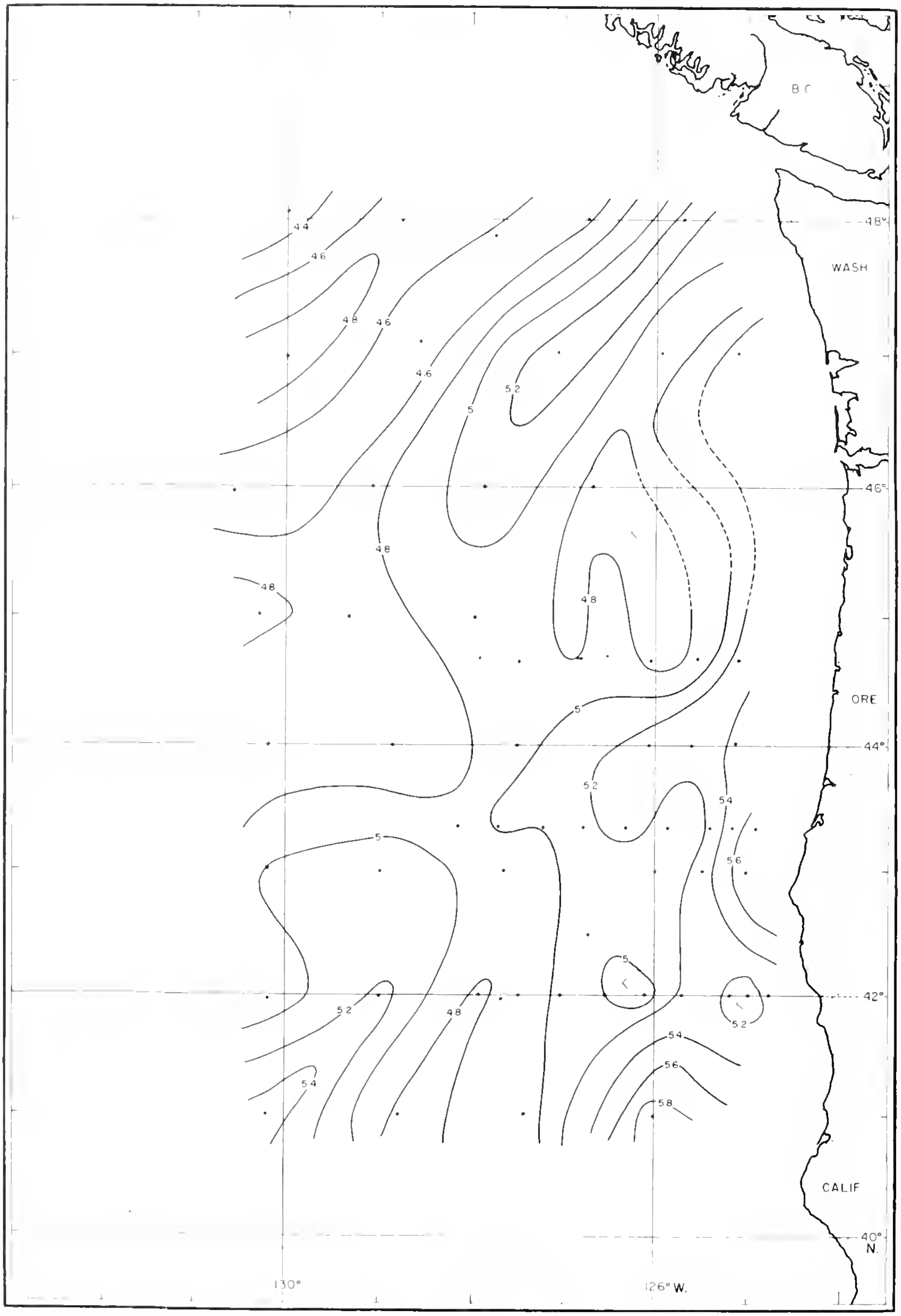

Figure 35.--Horizontal distribution of temperature at 500 m., July 1963. Contour Interval is 0.2° C.

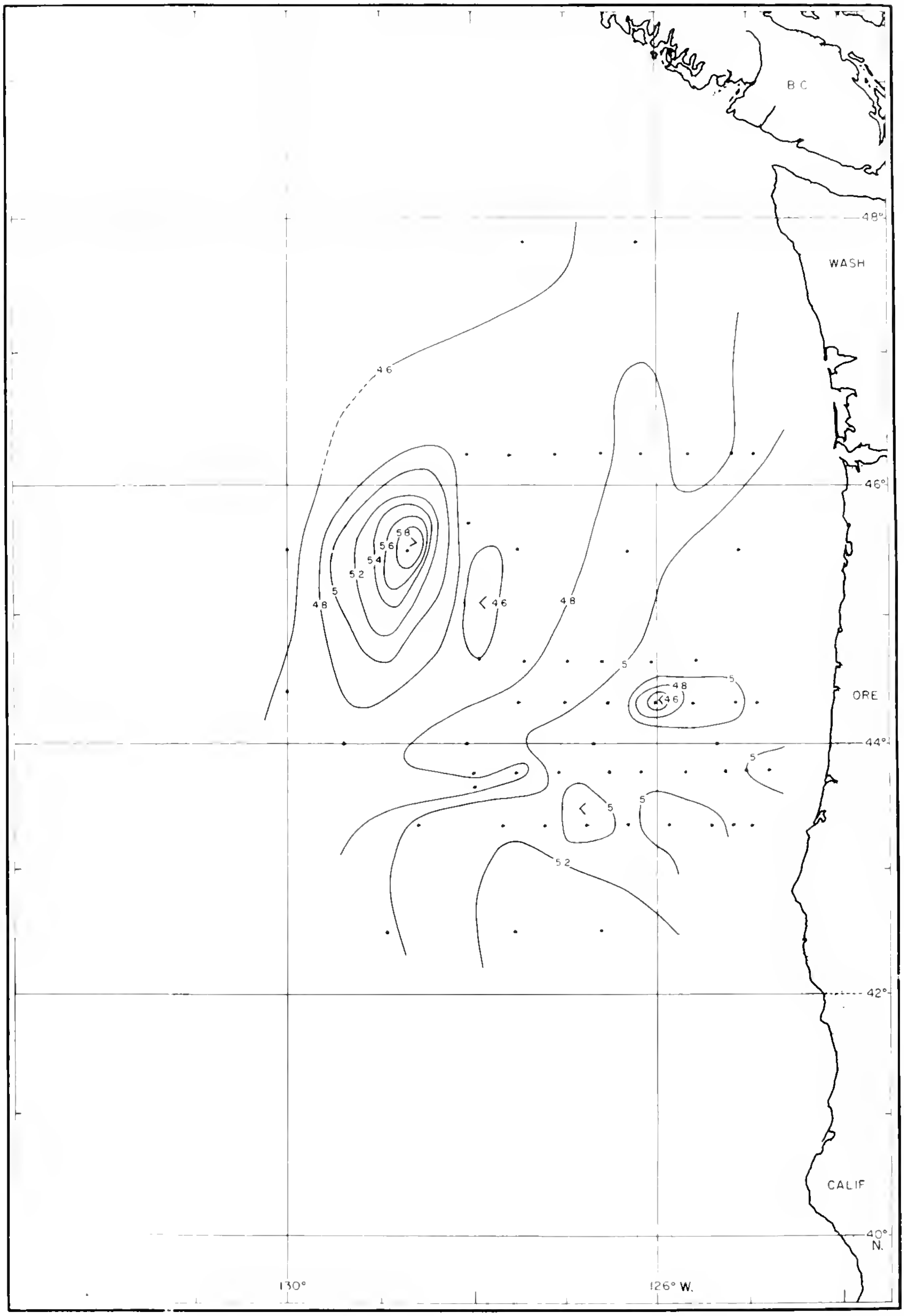

Figure 36.--Horizontal distribution of temperature at 500 m., July 1964. Contour interval is 0.2^{o} C.

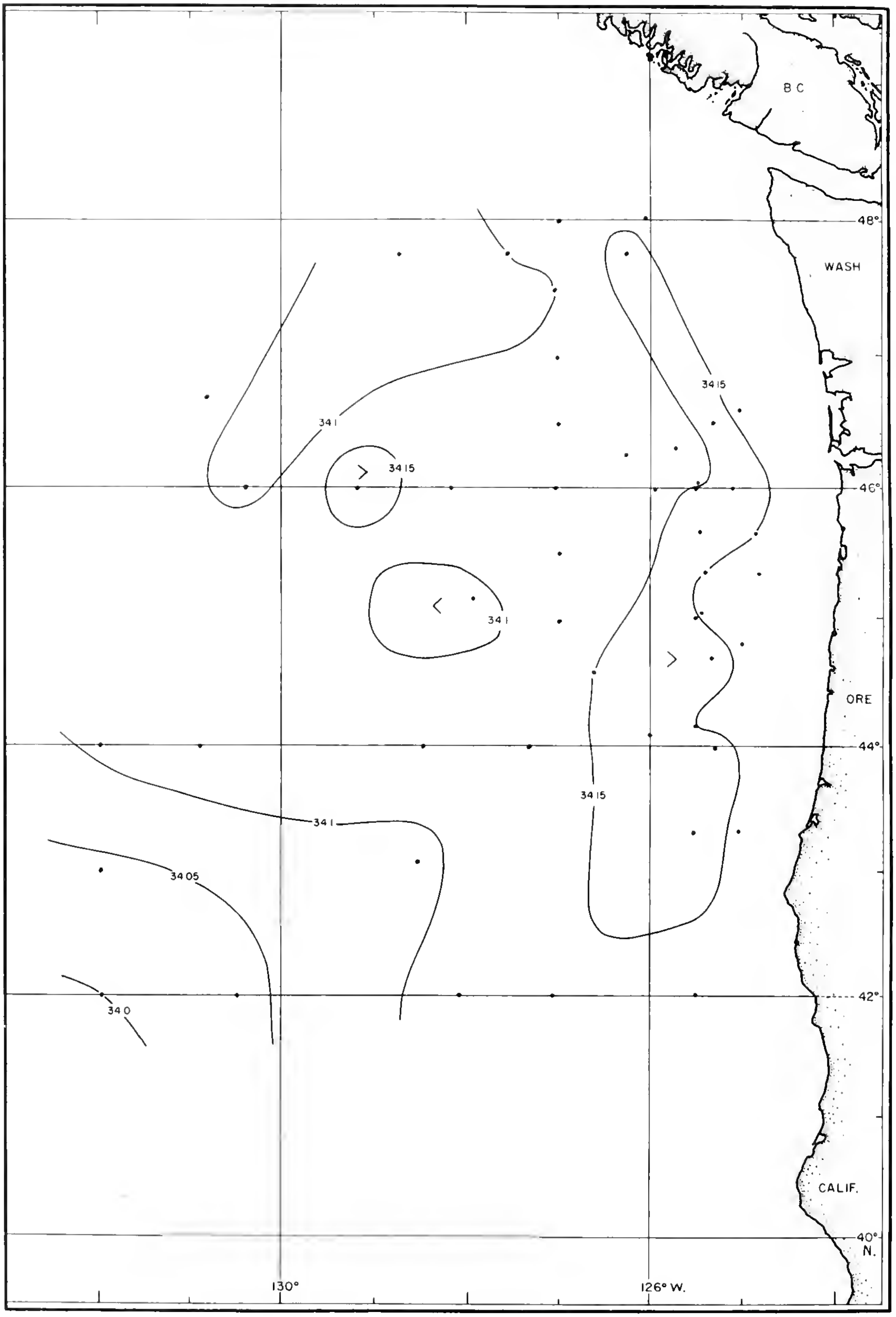

Figure 37.--Horizontal distribution of salinity at 500 m., July 1961. Contour interval is 0.05 p.p.t.

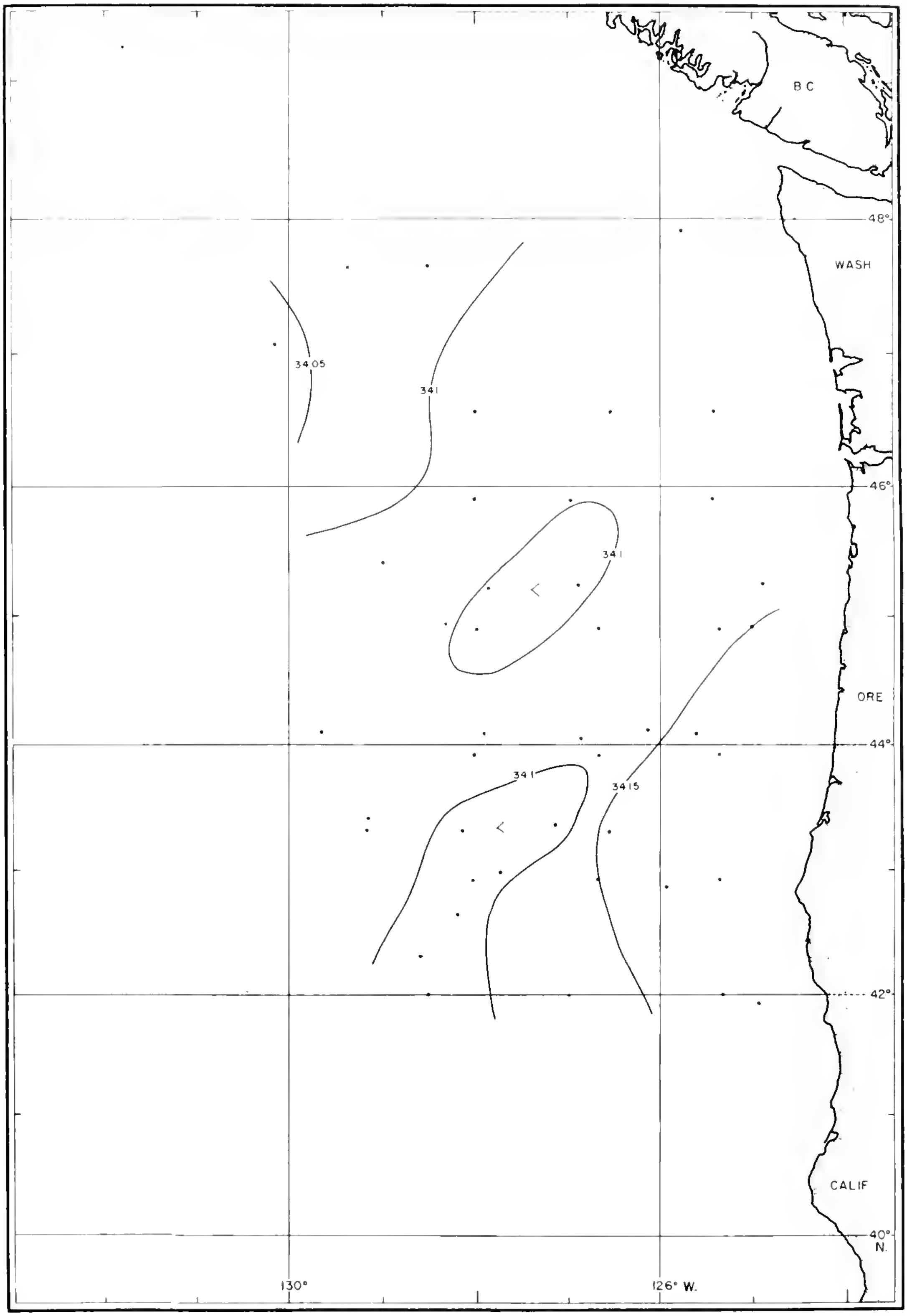

Figure 38.--Horizontal distribution of salinity at 500 m., July 1962. Contour interval is 0.05 p.p.t.

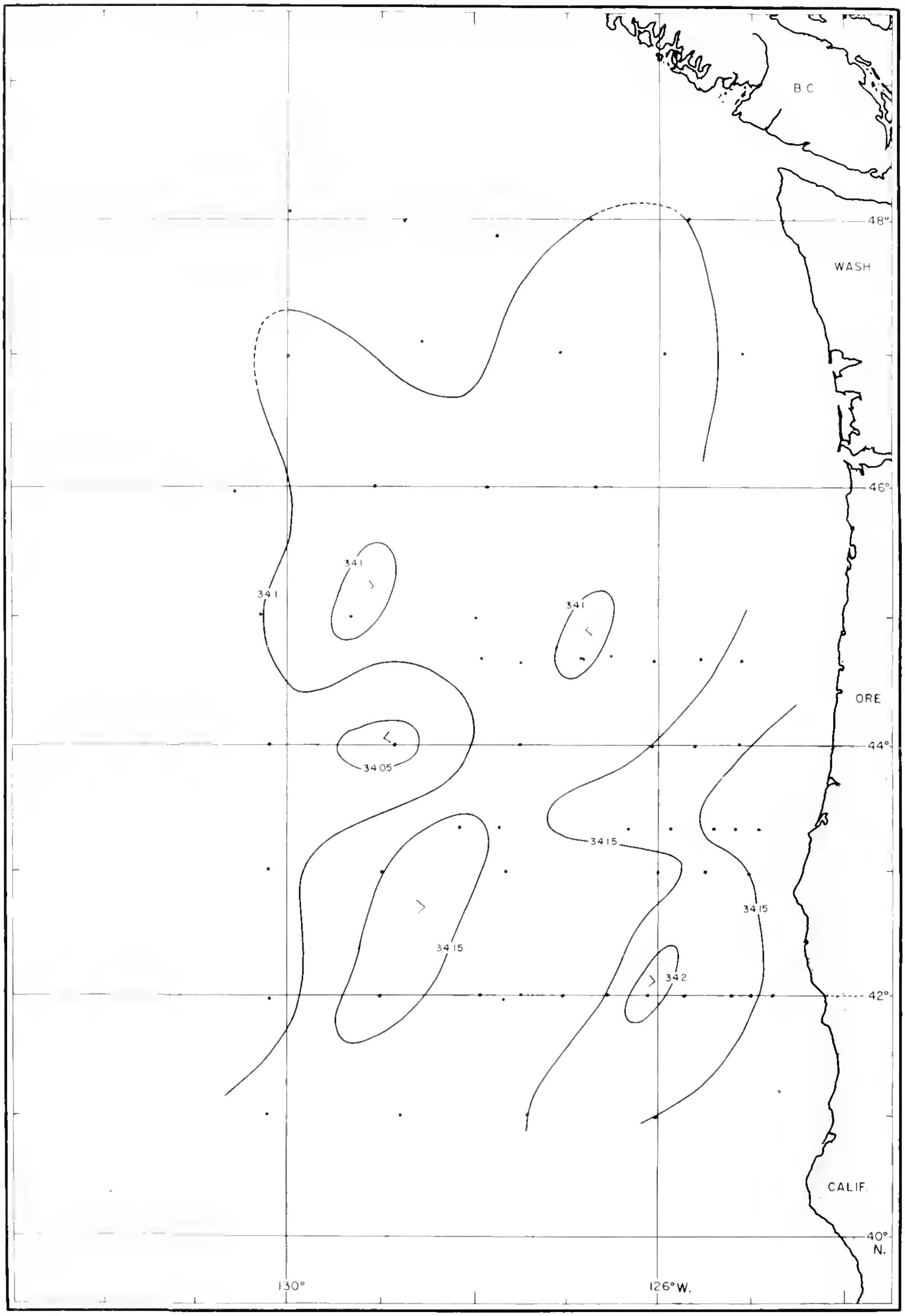

Figure 39.--Horizontal distribution of salinity at 500 m., July 1963. Contour interval is 0.05 p.p.t.

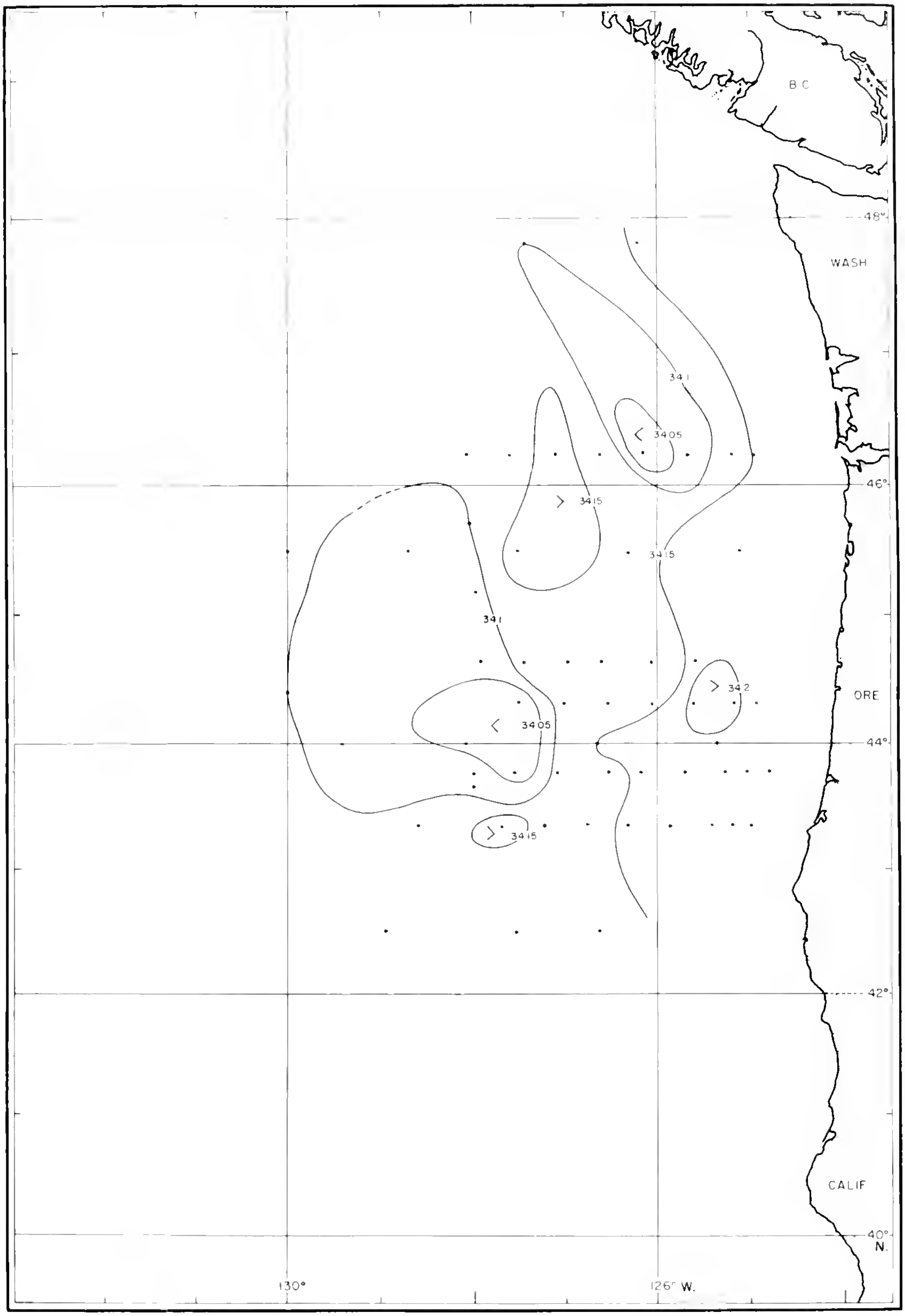

Figure 40.--Horizontal distribution of salinity at 500 m., July 1964. Contour interval is 0.05 p.p.t.

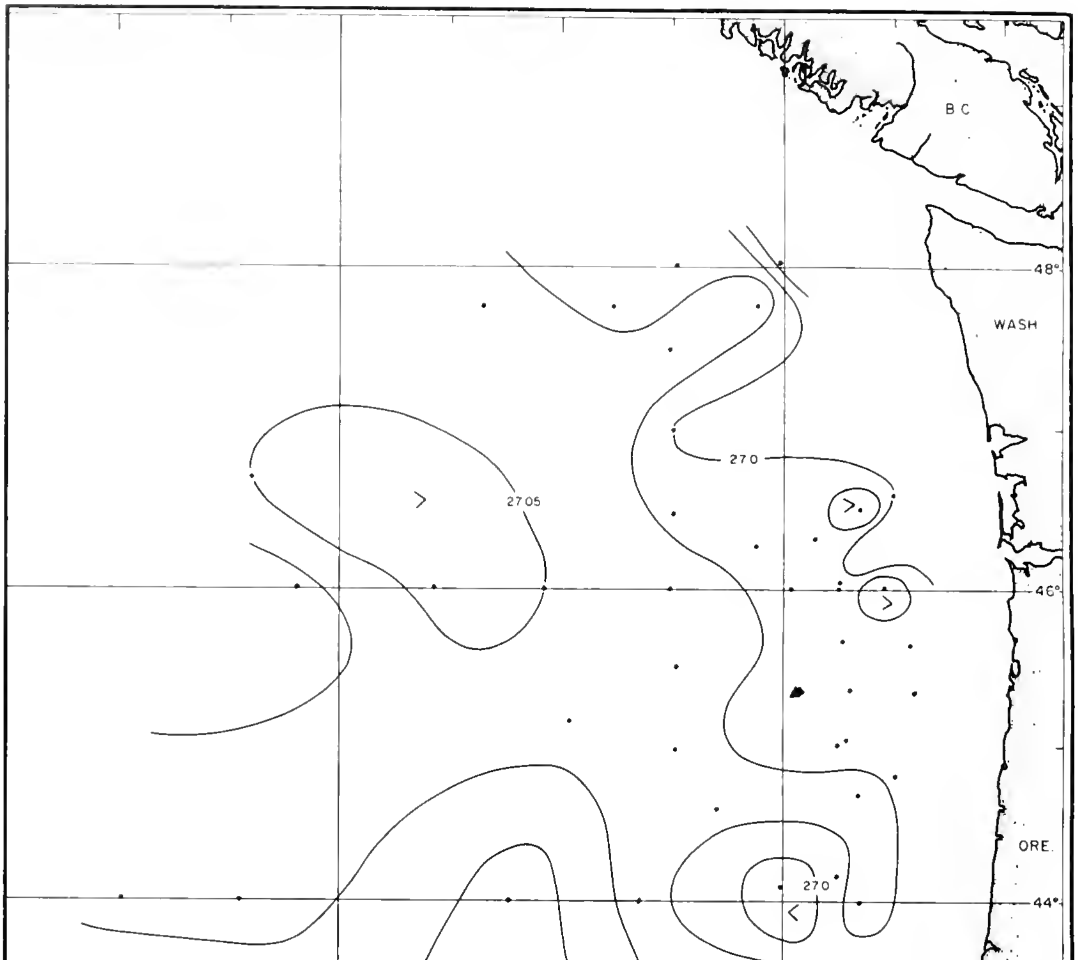

Figure 41.--Horizontal distribution of density at 500 m., July 1961. Contour interval is 0.025 σ_t unit.

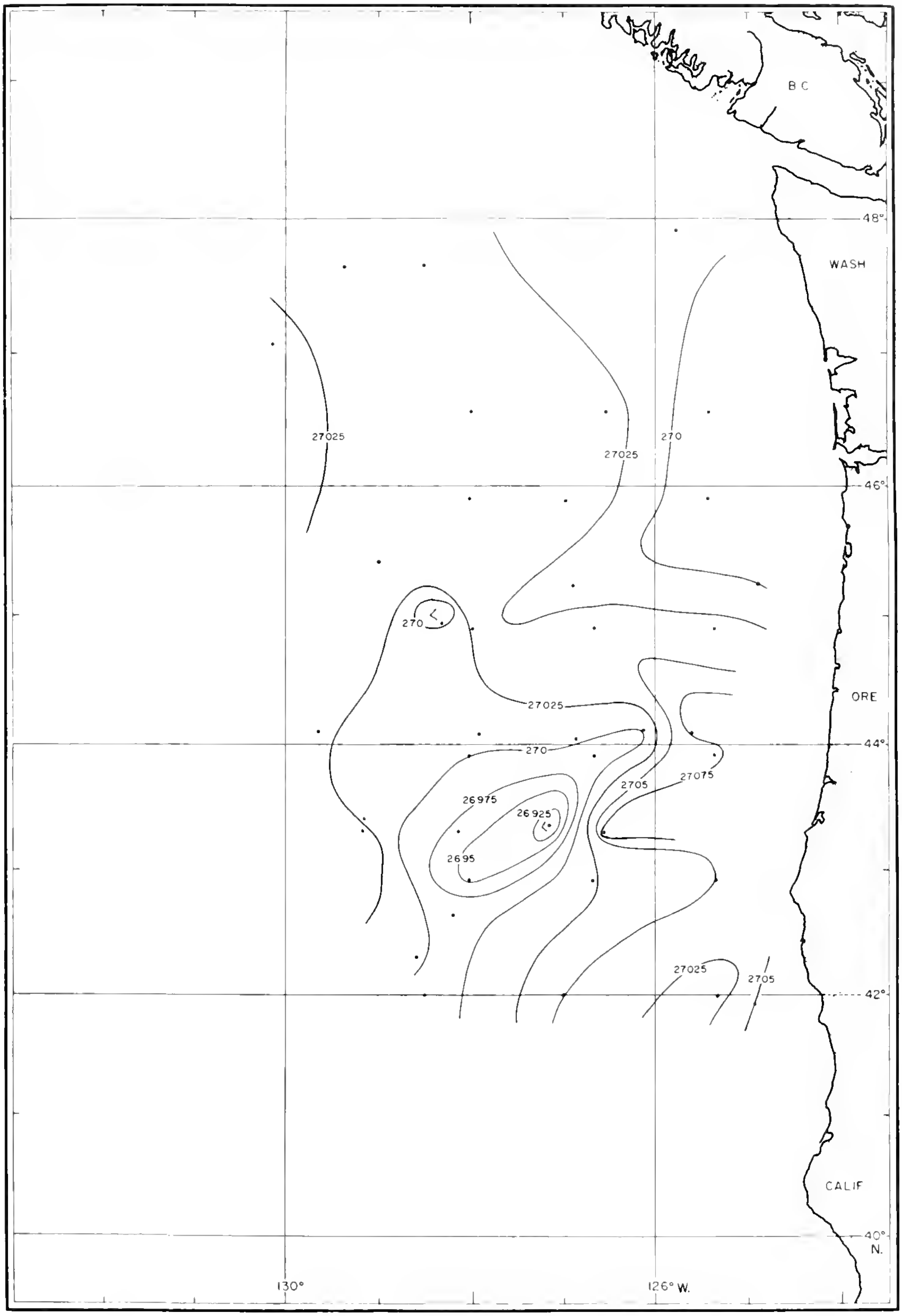

Figure 42.--Horizontal distribution of density at 500 m., July 1962. Contour interval is 0.025 σ_t unit.

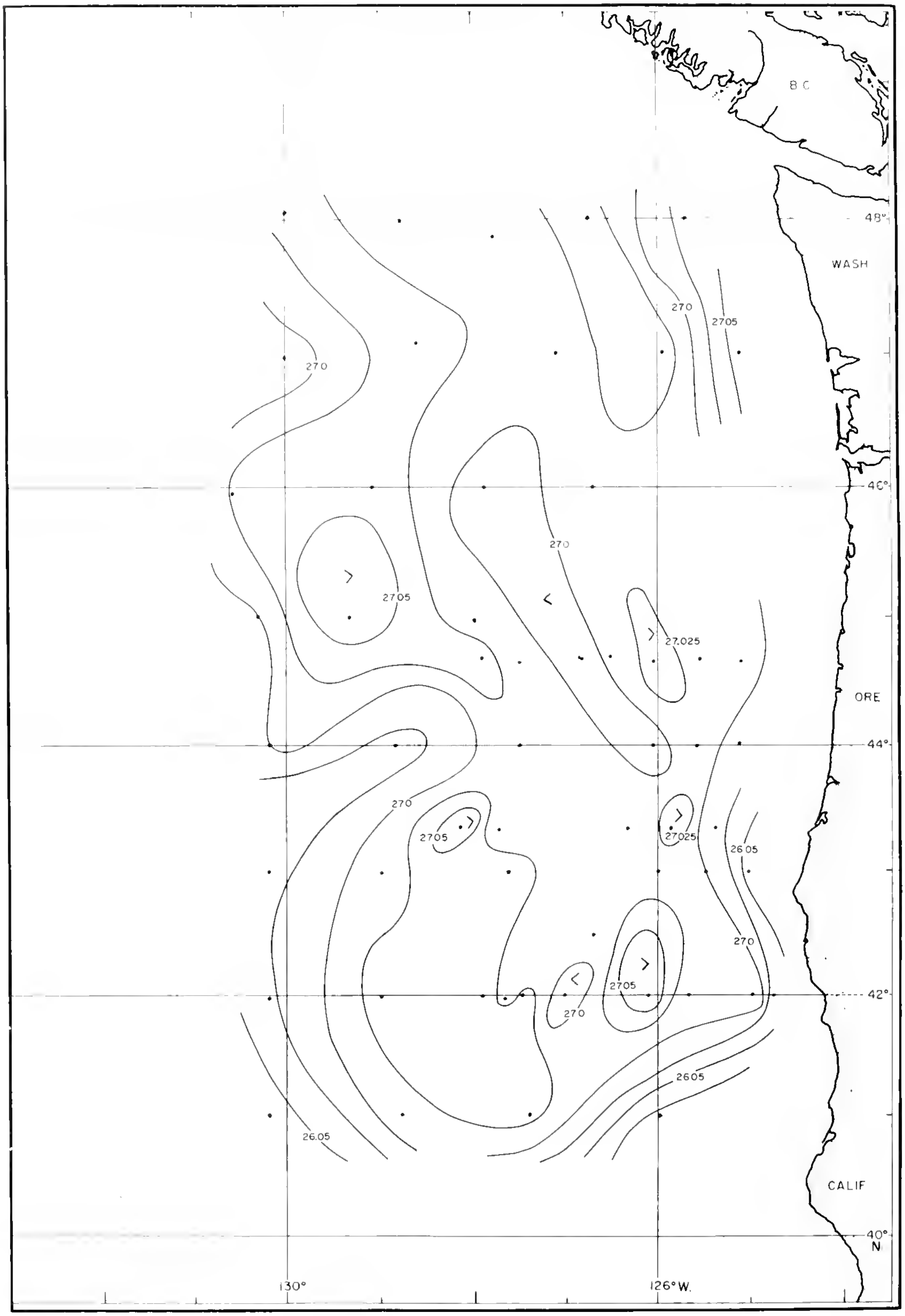

Figure 43.--Horizontal distribution of density at 500 m., July 1963. Contour interval is 0.025 σ_t unit.

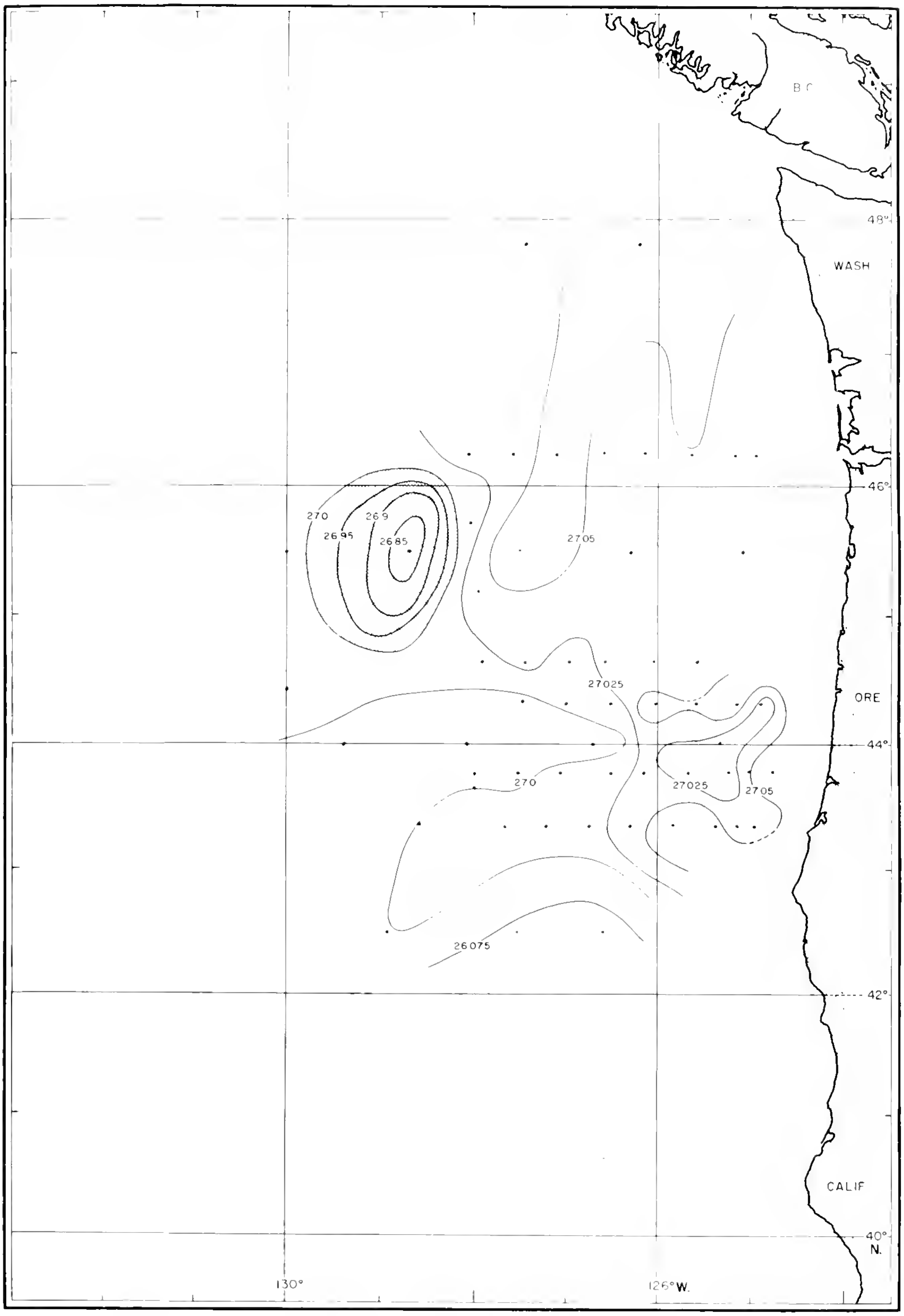

Figure 44.--Horizontal distribution of density at 500 m., July 1964. Contour interval is 0.025 σ_t unit except where shaded.

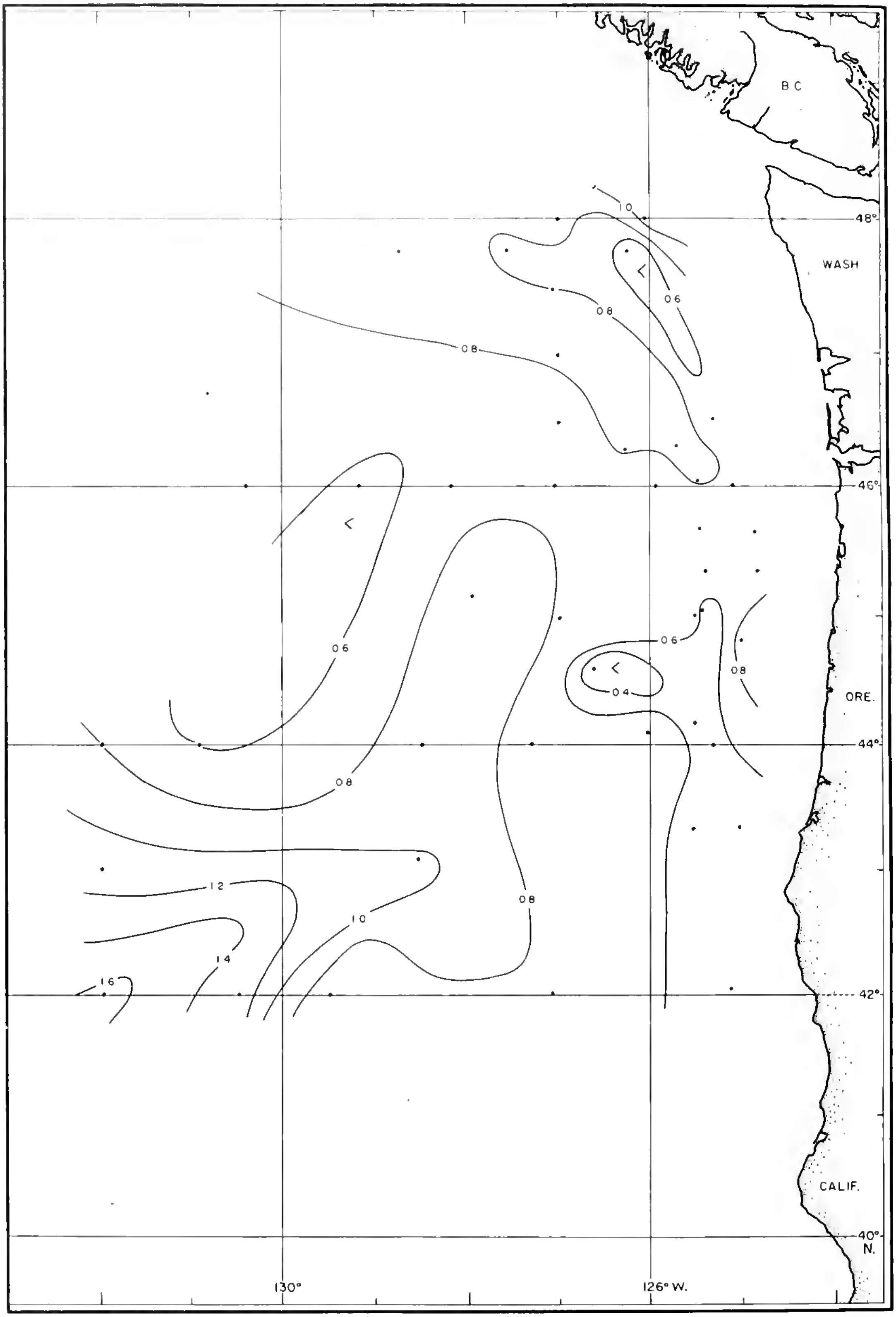

Figure 45.--Horizontal distribution of oxygen concentration at 500 m., July 1961. Contour interval is 0.2 ml./1.

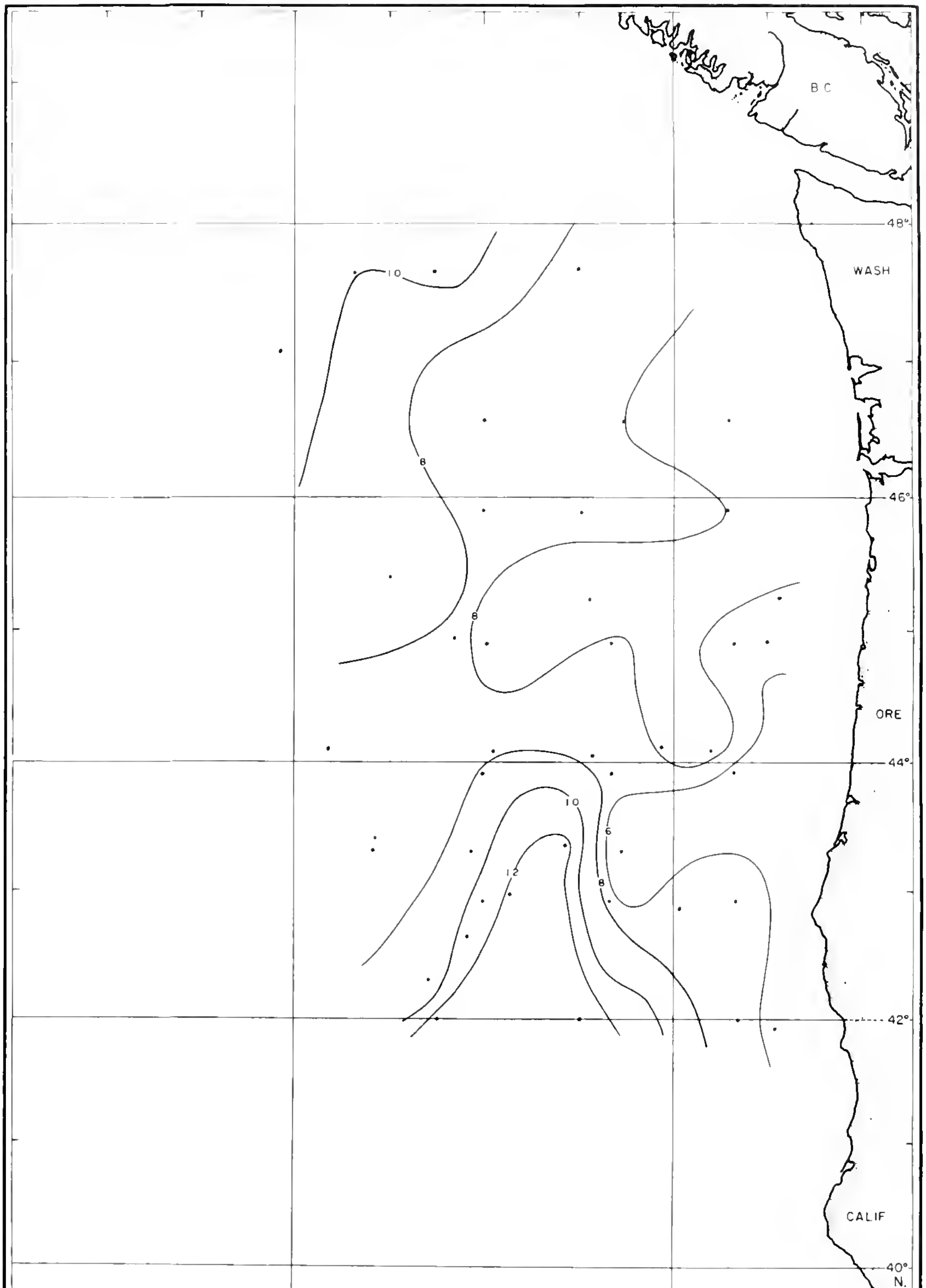

Figure 46.--Horizontal distribution of oxygen concentration at 500 m., July 1962. Contour interval is 0.2 ml./l.

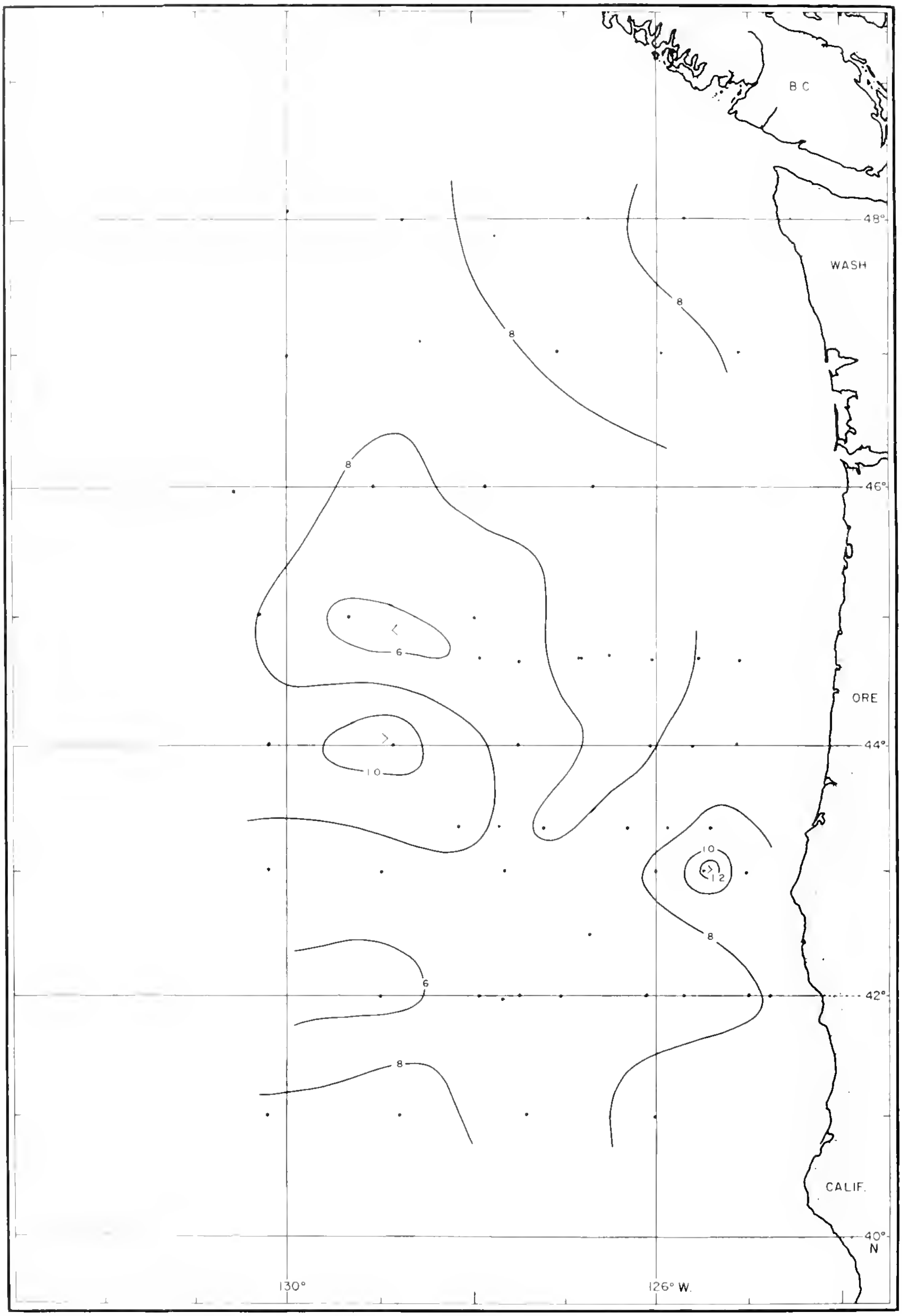

Figure 47.--Horizontal distribution of oxygen concentration at 500 m., July 1963. Contour interval is 0.2 ml/l.

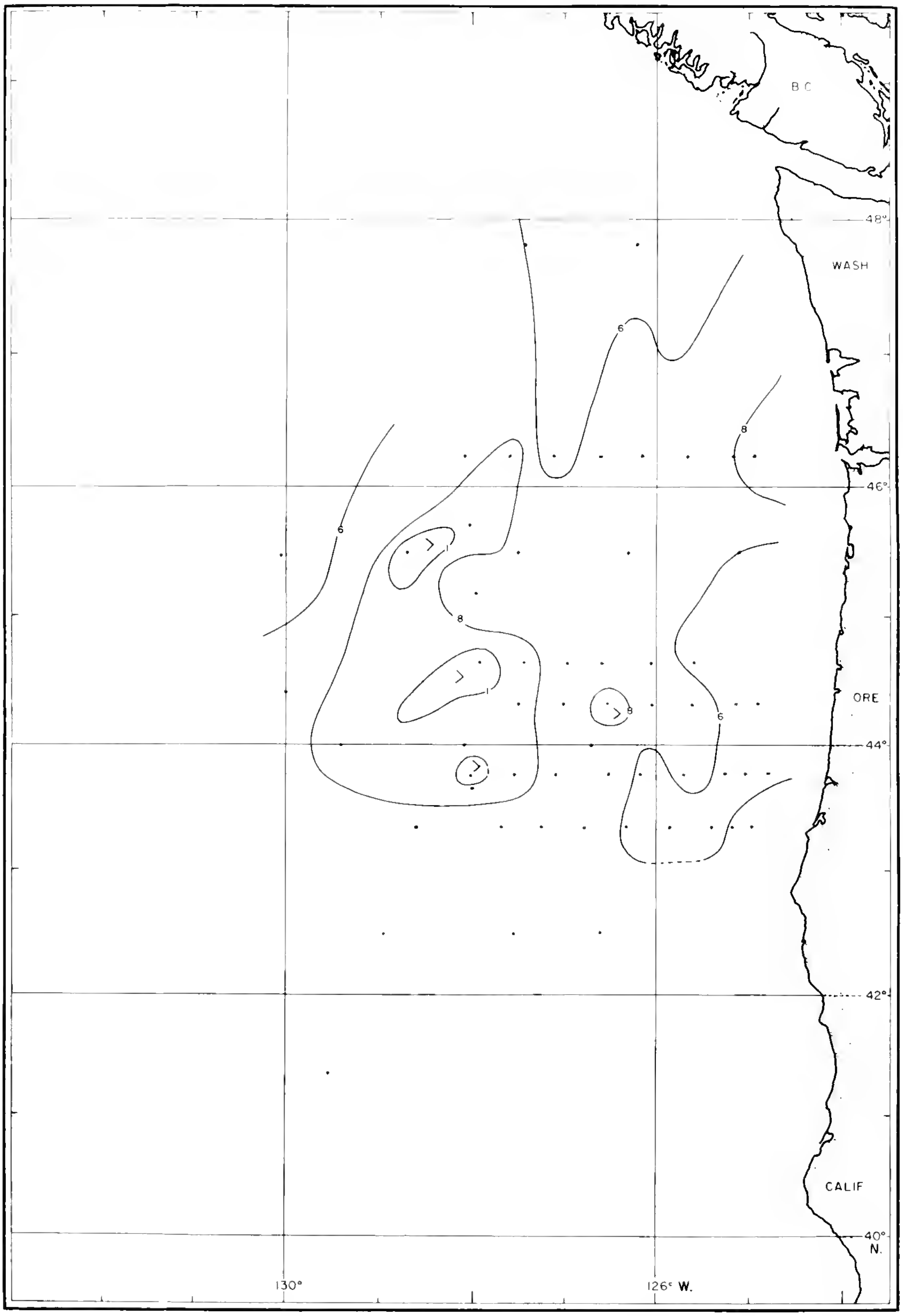

Figure 48.--Horizontal distribution of oxygen concentration at 500 m., July 1964. Contour interval is 0.2 ml./l.

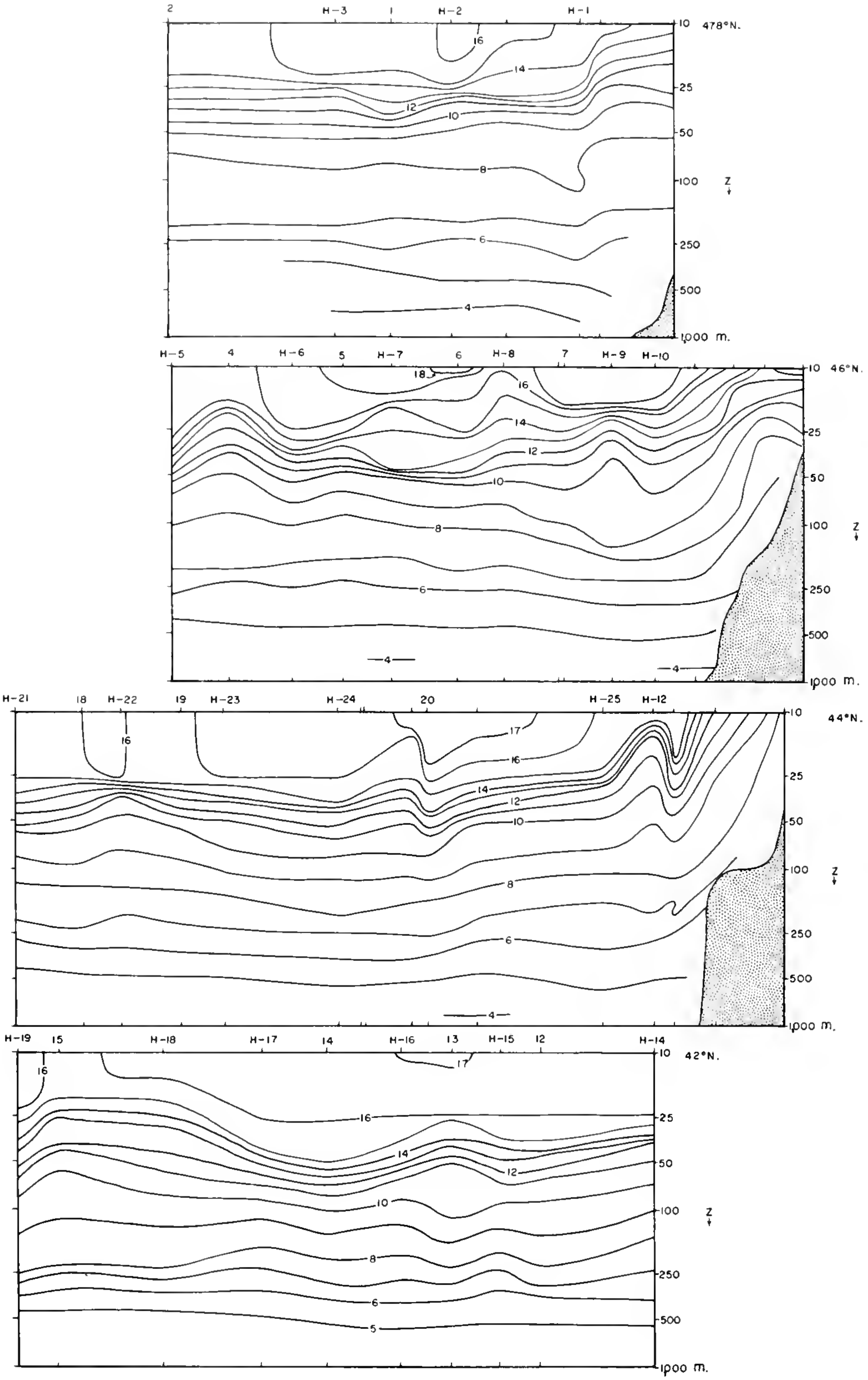

Figure 49.--Vertical profiles of temperature in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic.

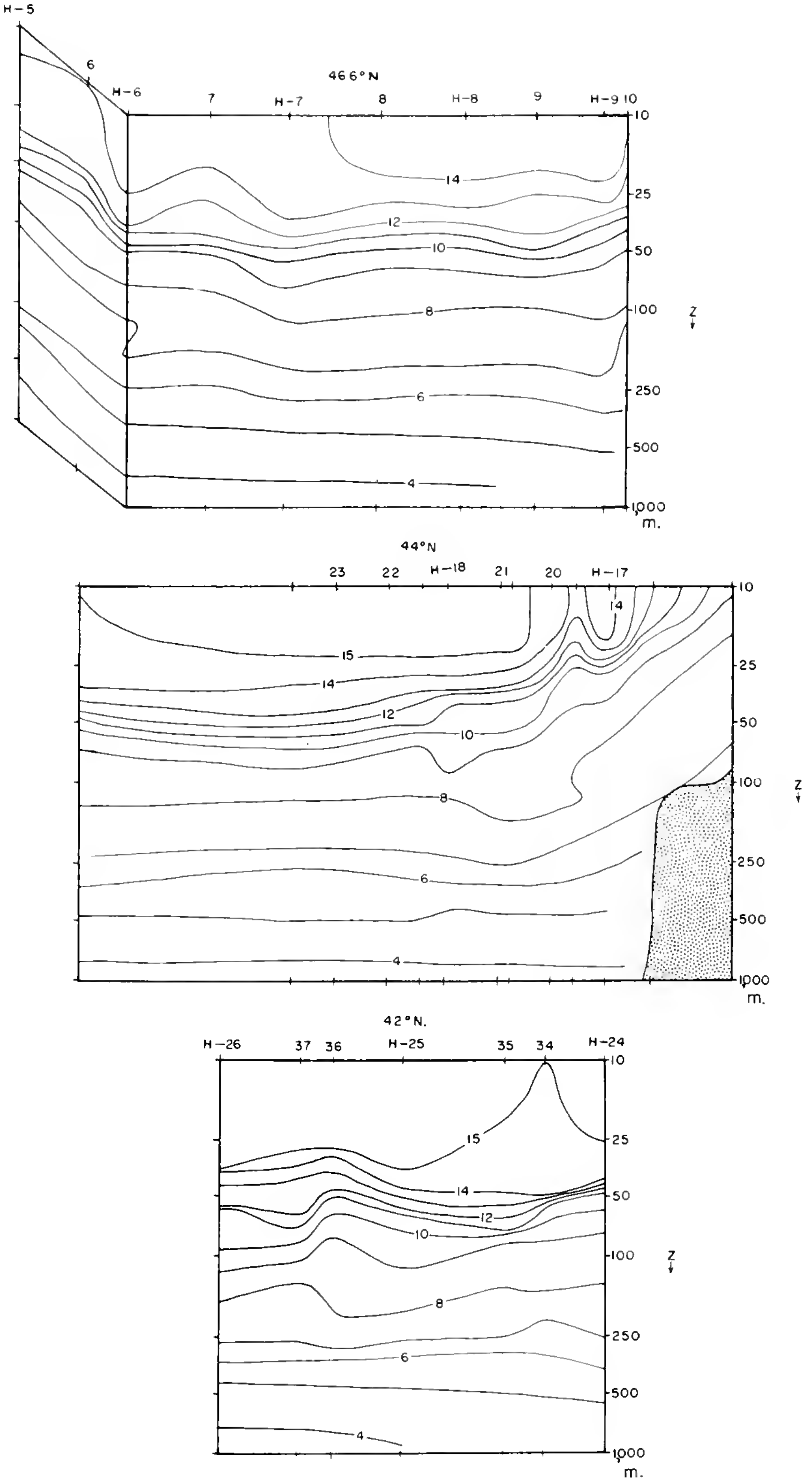

Figure 50.--Vertical profiles of temperature in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic.

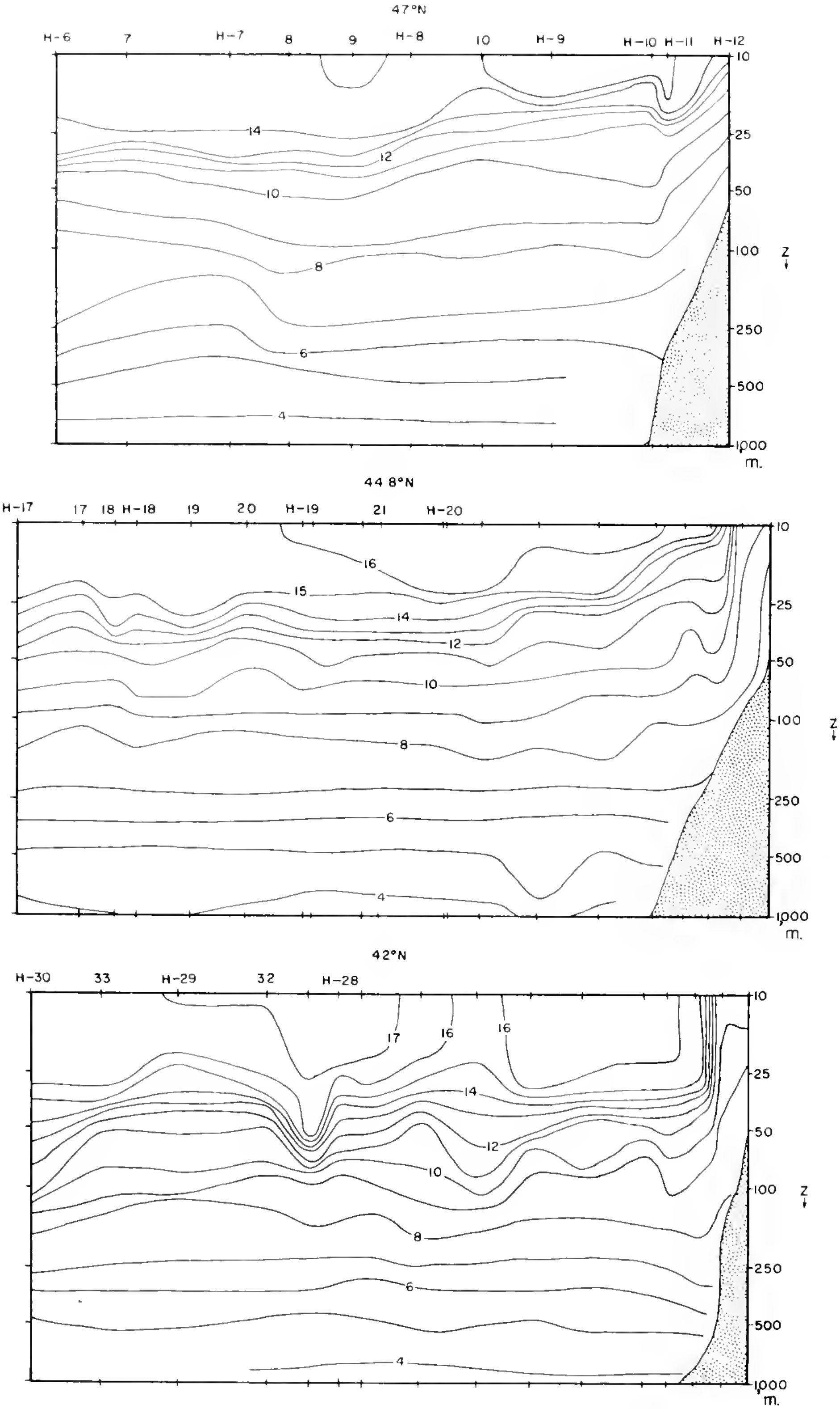

Figure 51.--Vertical profiles of temperature in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic.

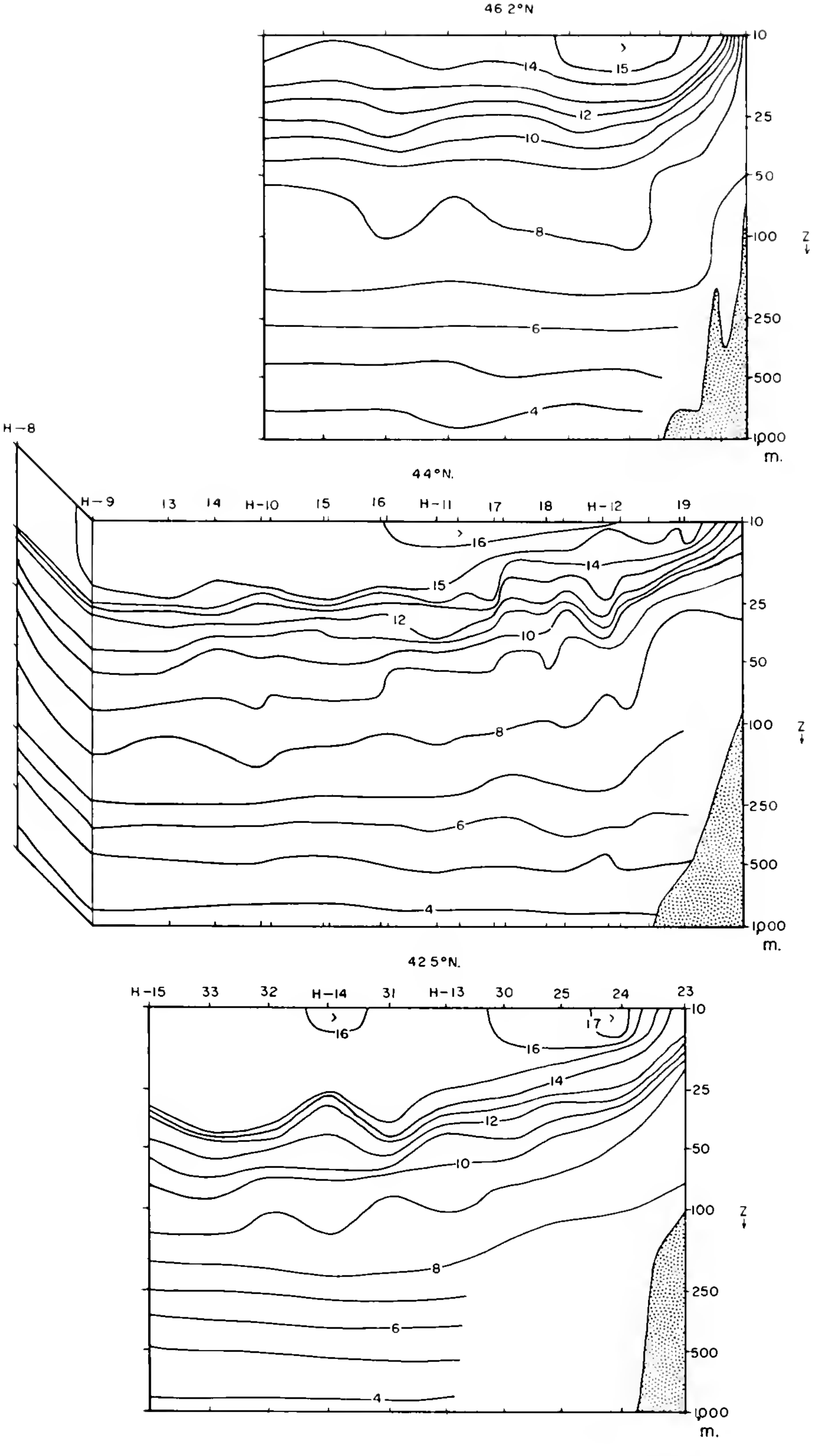

Figure 52.--Vertical profiles of temperature in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 1° C. Depth scale is logarithmic.

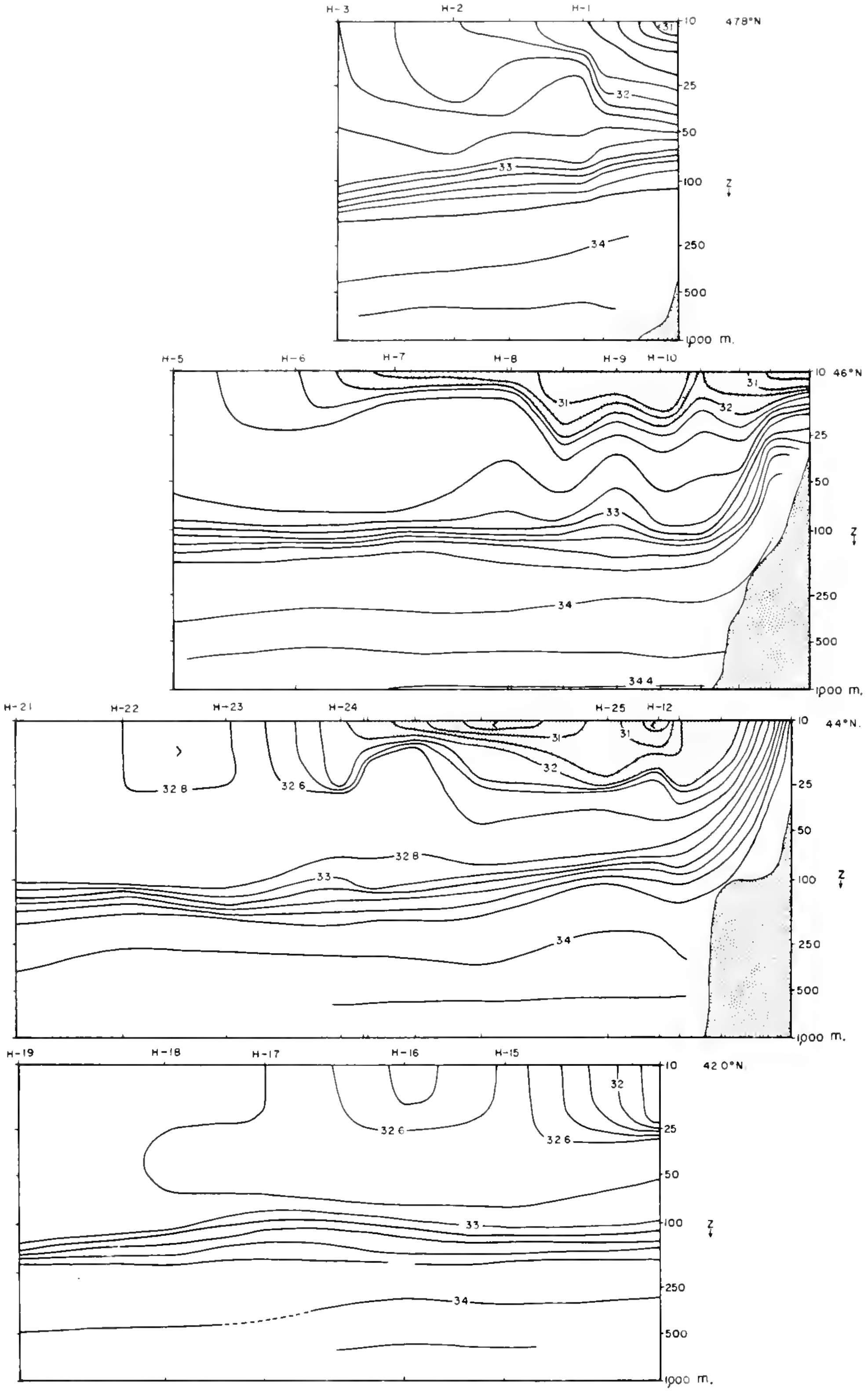

Figure 53.--Vertical profiles of salinity in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. except where shaded. Depth scale is logarithmic.

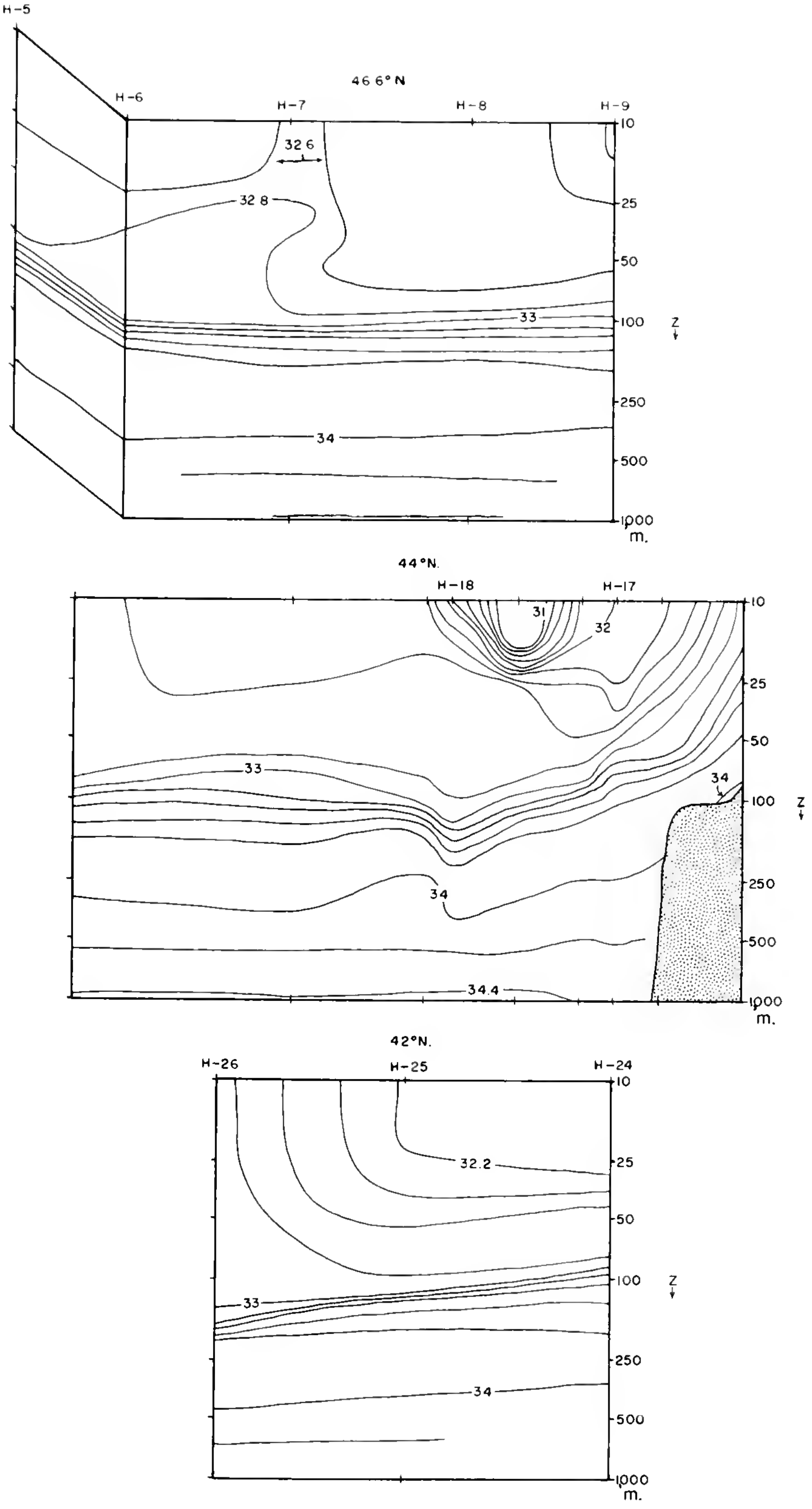

Figure 54.--Vertical profiles of salinity in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. Depth scale is logarithmic.

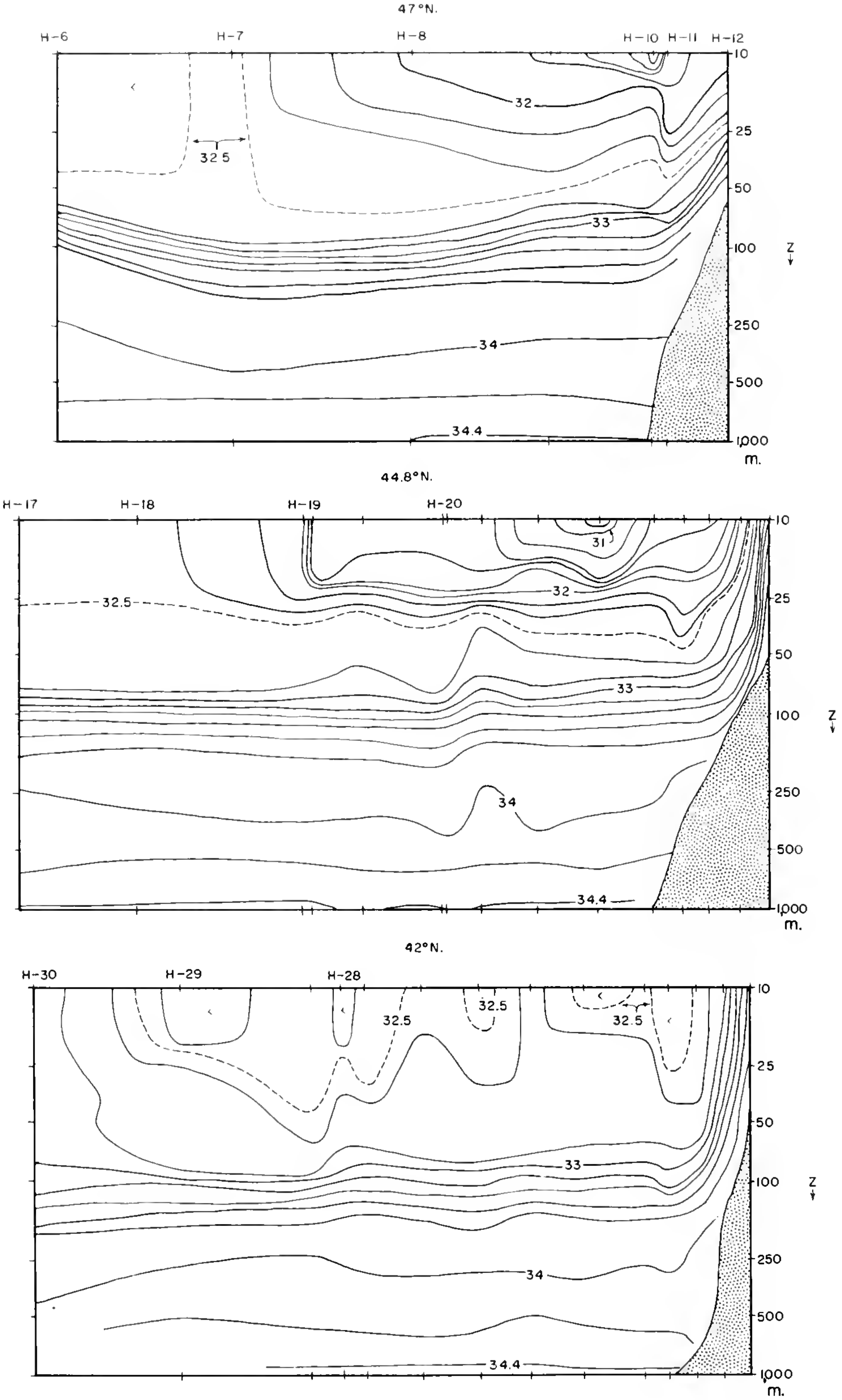

Figure 55.--Vertical profiles of salinity in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. Depth scale is logarithmic.

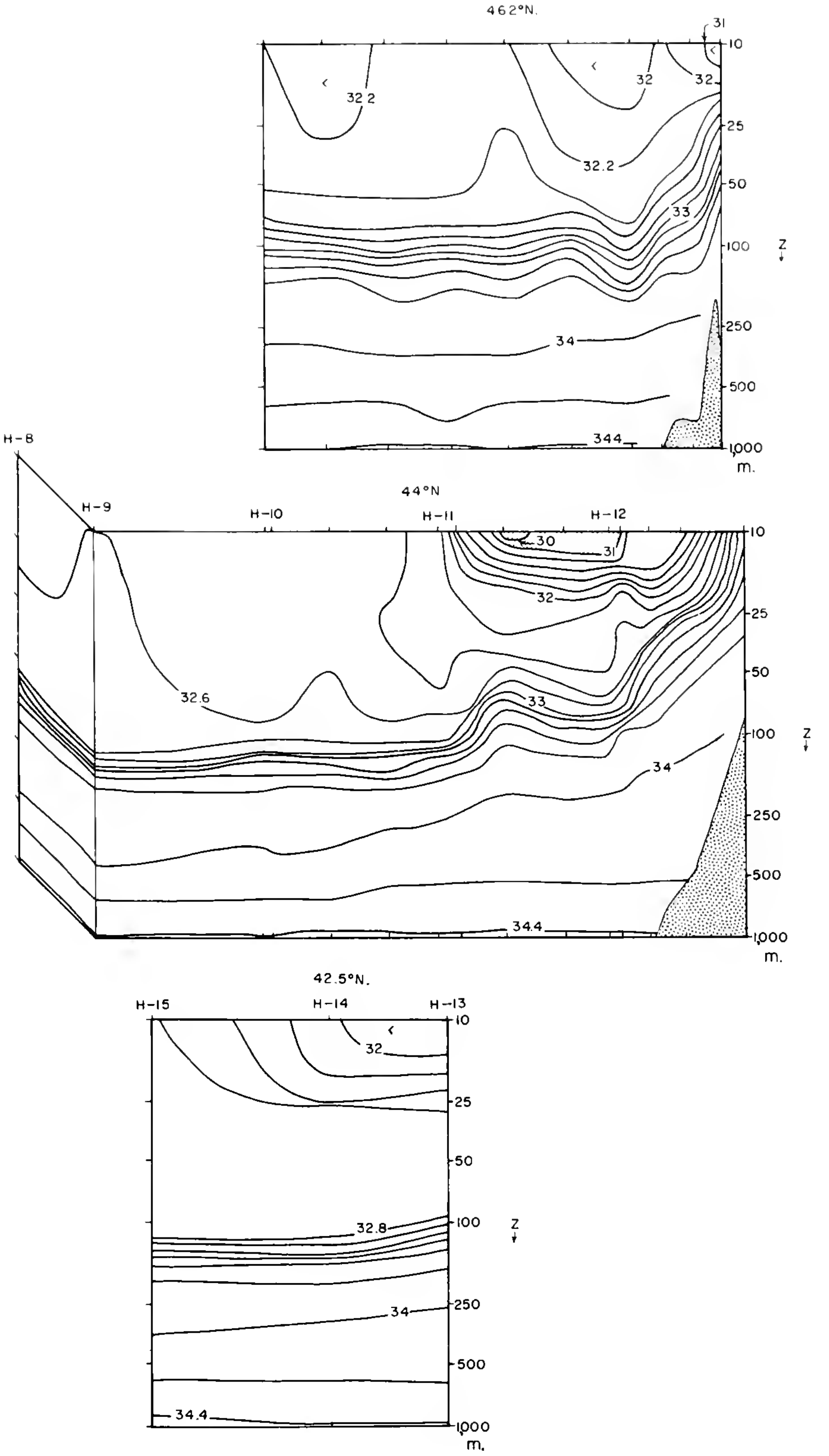

Figure 56.--Vertical profiles of salinity in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.2 p.p.t. except where shaded. Depth scale is logarithmic.

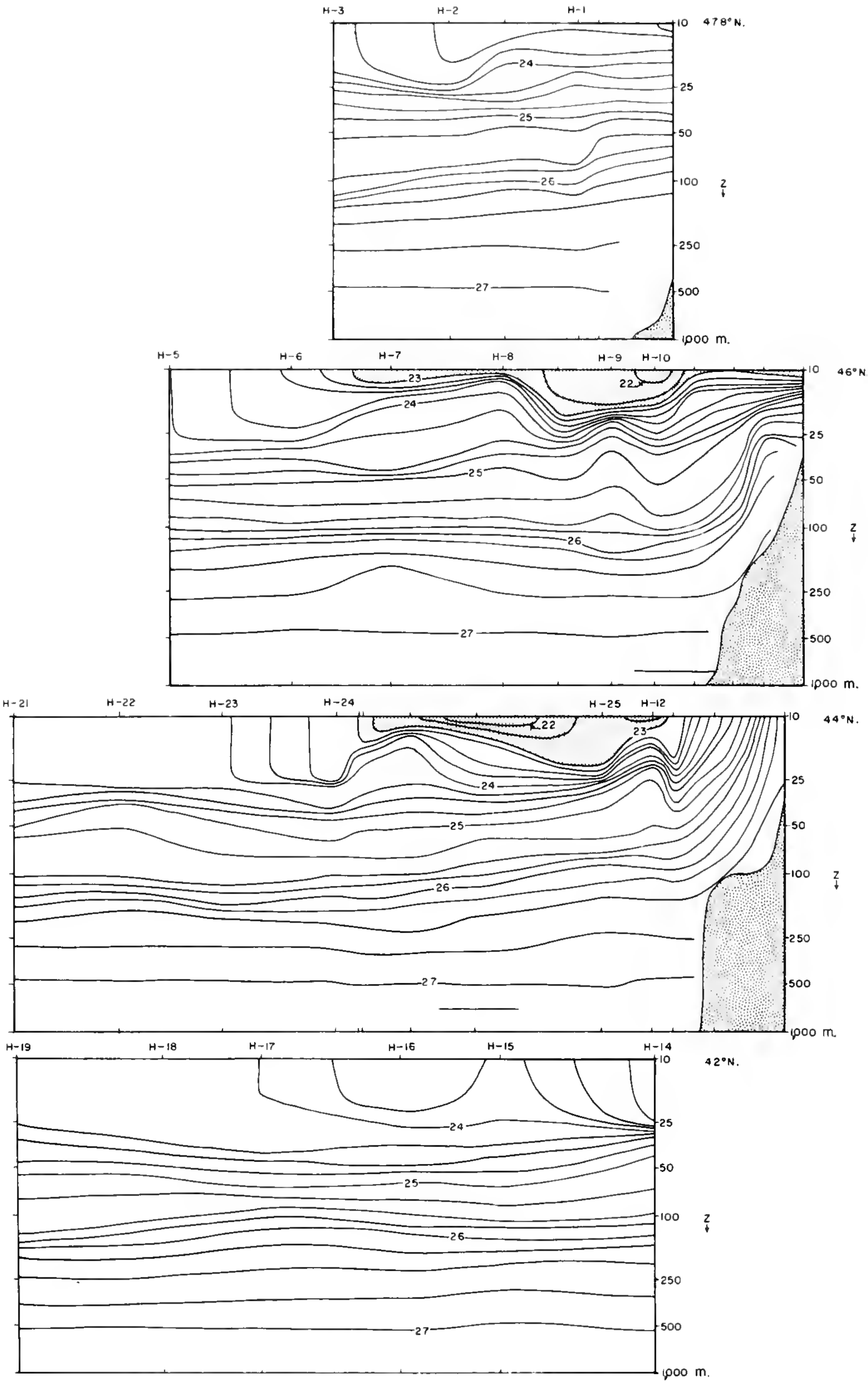

Figure 57.--Vertical profiles of density in July 1961 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit except where shaded. Depth scale is logarithmic.

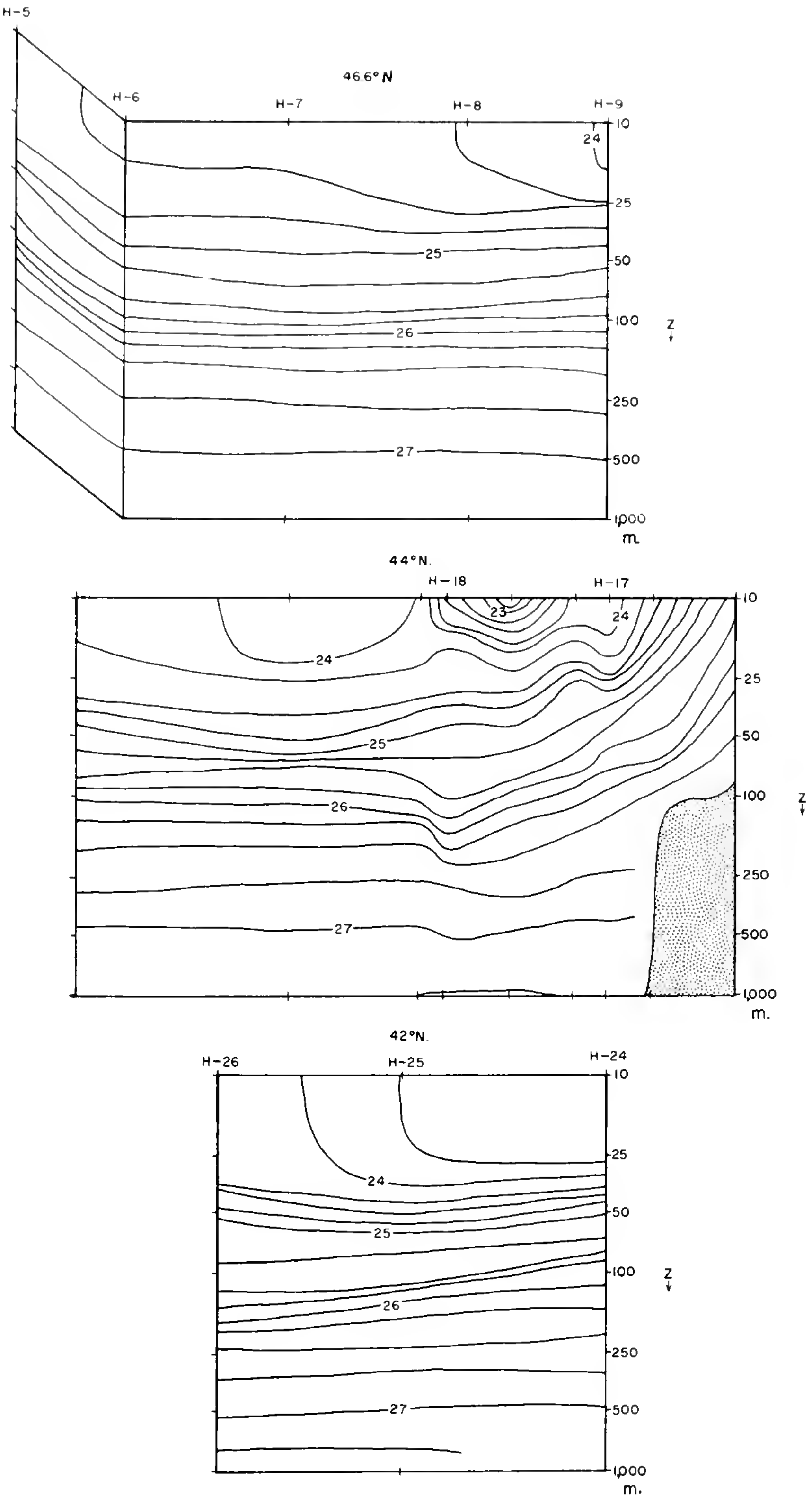

Figure 58.--Vertical profiles of density in July 1962 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit. Depth scale is logarithmic.

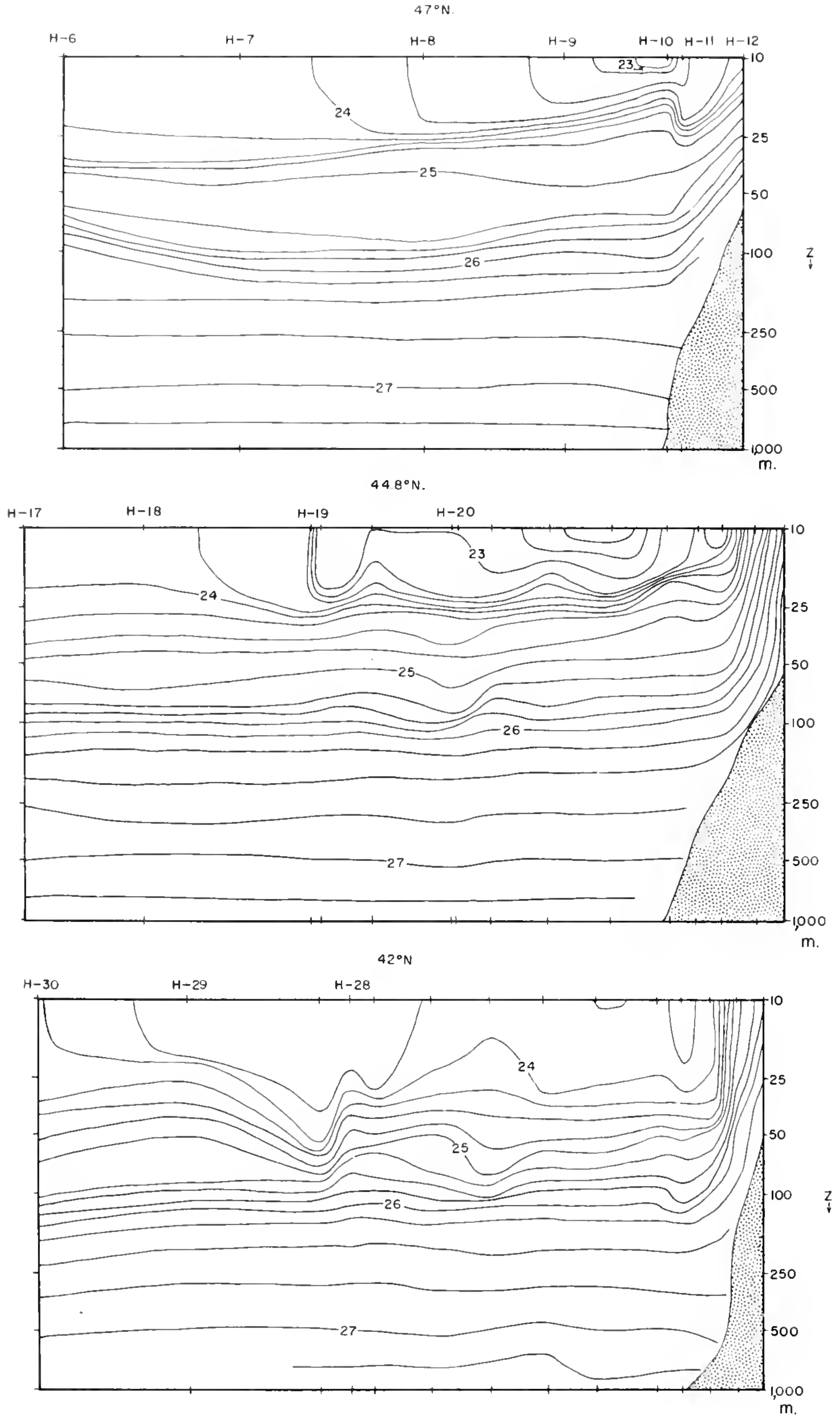

Figure 59.--Vertical profiles of density in July 1963 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit. Depth scale is logarithmic.

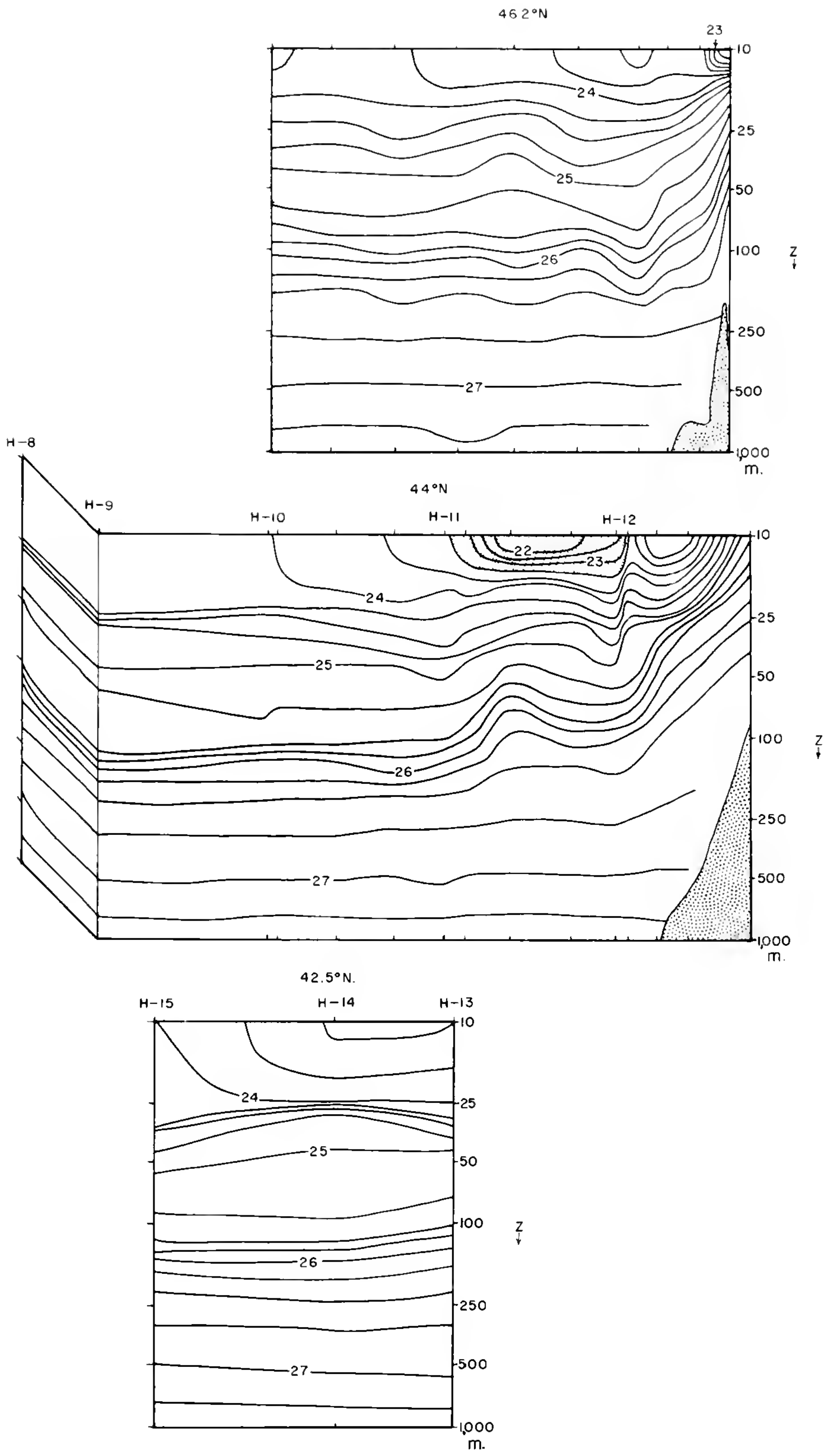

Figure 60.--Vertical profiles of density in July 1964 along specified lines of latitude. Longitudinal relationships between profiles are preserved. Sea floor is stippled. Contour interval is 0.25 σ_t unit except where shaded. Depth scale is logarithmic.

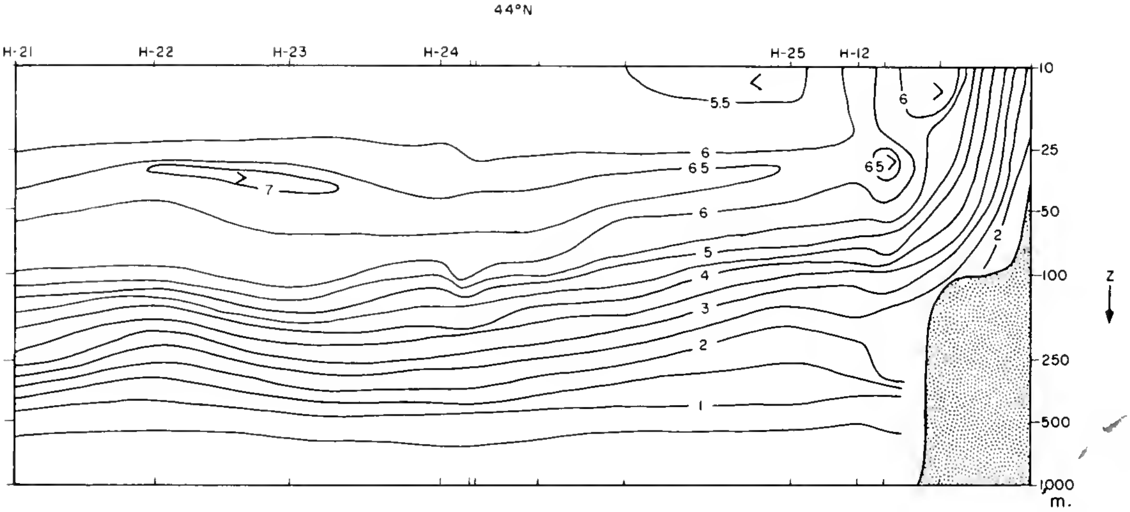

Figure 61.--Vertical profile of oxygen concentration along lat. 44° N., July 1961. Contour interval is 0.5 ml./1. Depth scale is logarithmic.

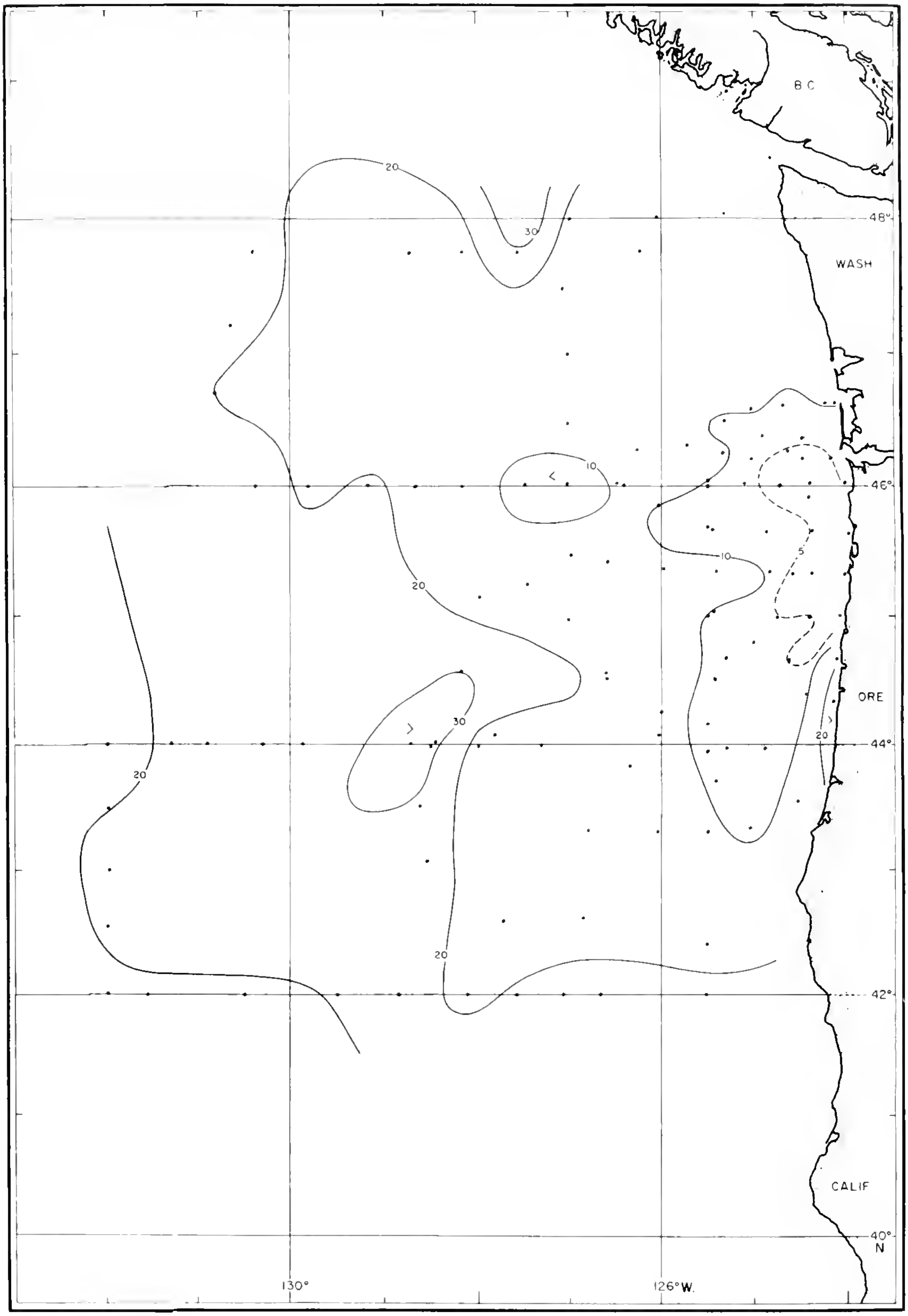

Figure 62.--Depth of the upper mixed layer, July 1961. Contour interval is 10 m.

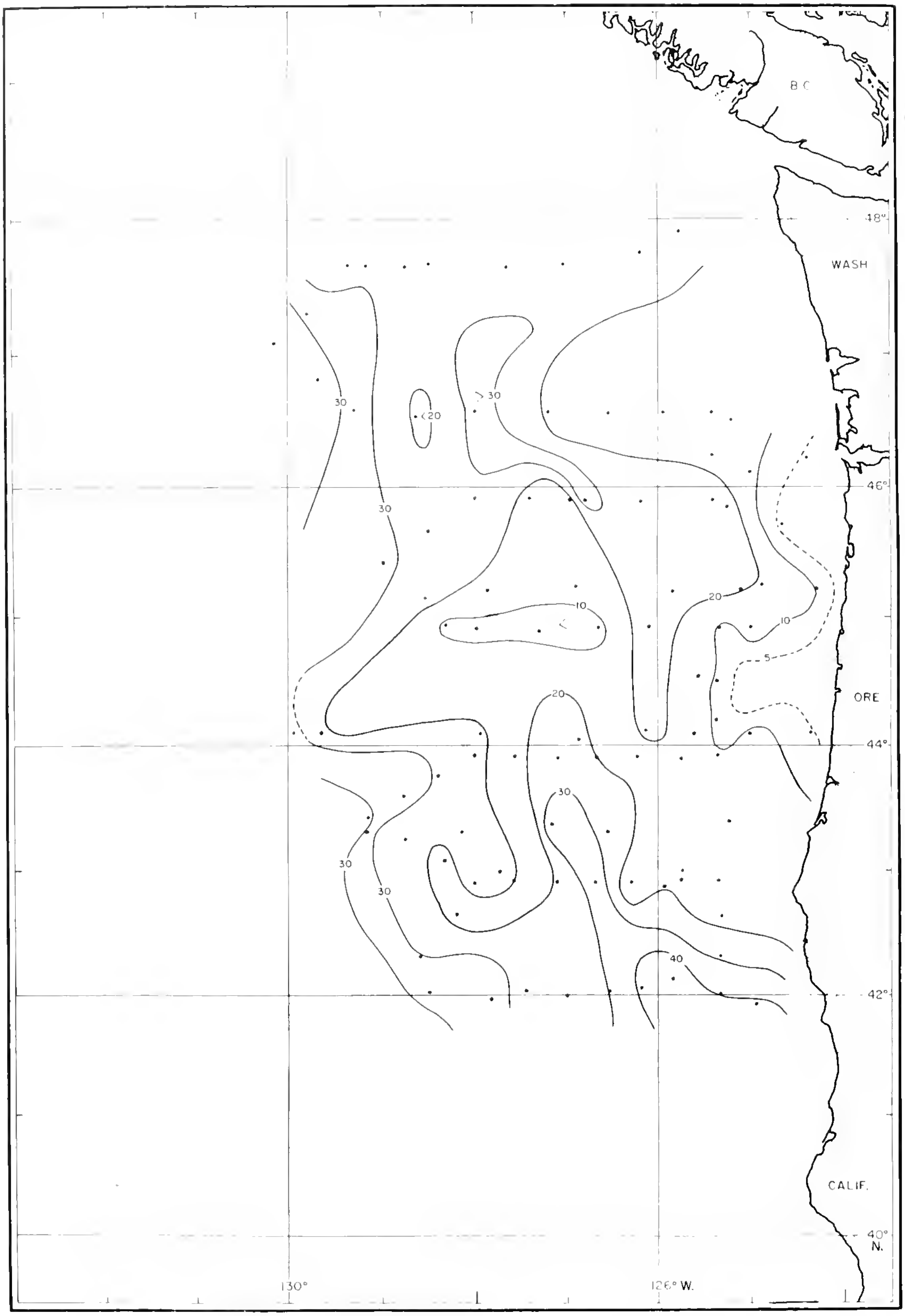

Figure 63.--Depth of the upper mixed layer, July 1962. Contour interval is 10 m.

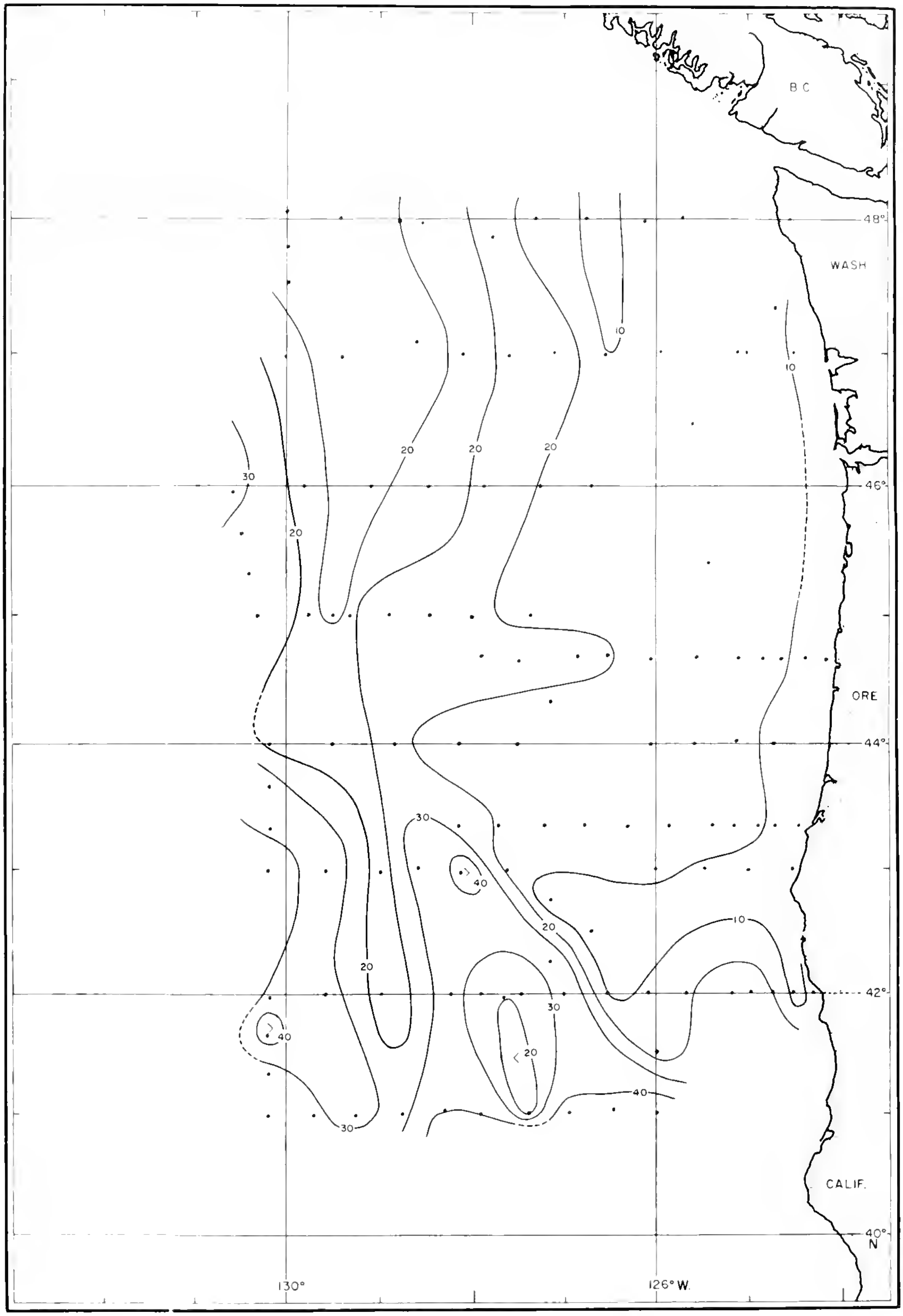

Figure 64.--Depth of the upper mixed layer, July 1963. Contour interval is 10 m.

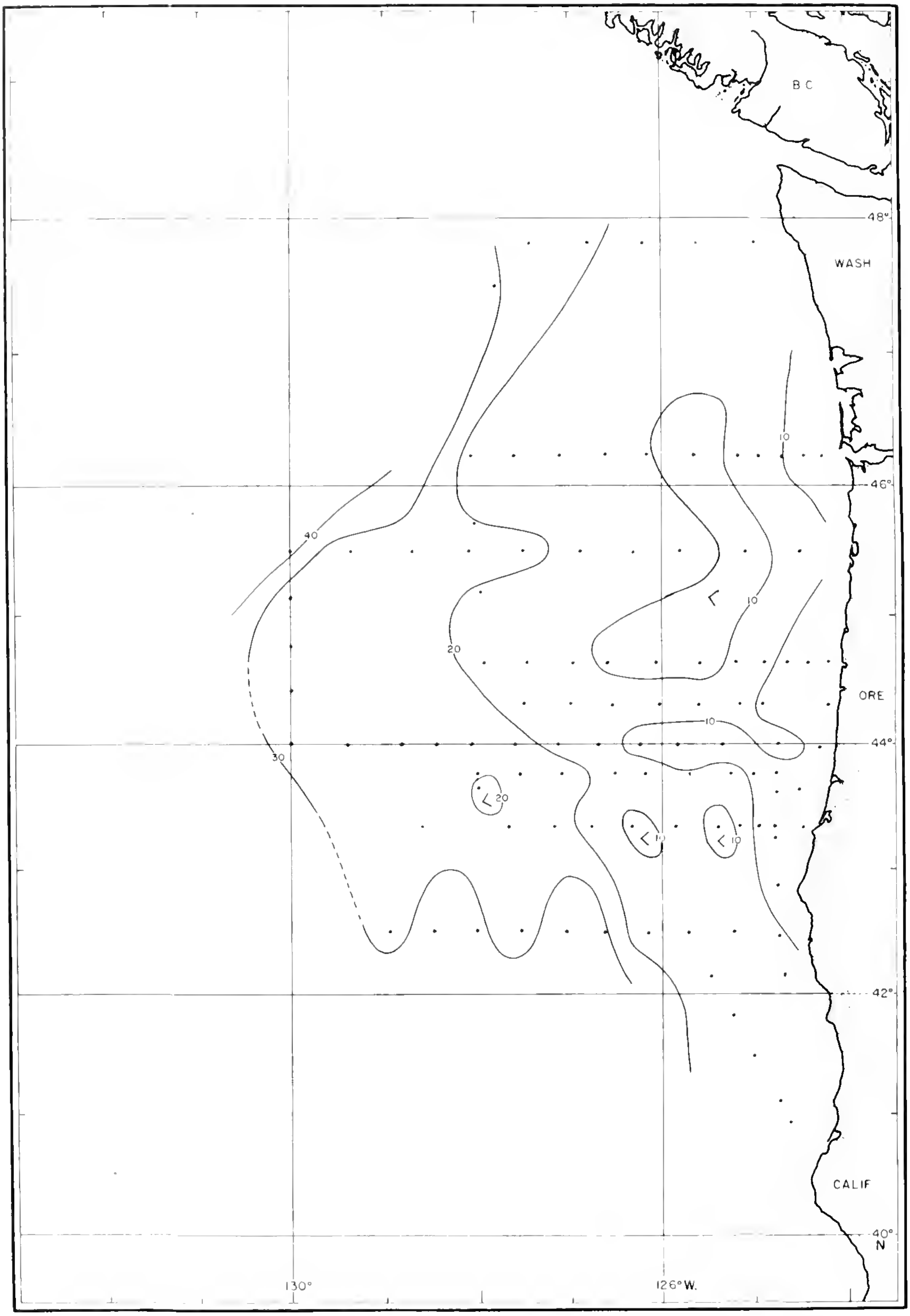

Figure 65.--Depth of the upper mixed layer, July 1964. Contour interval is 10 m.

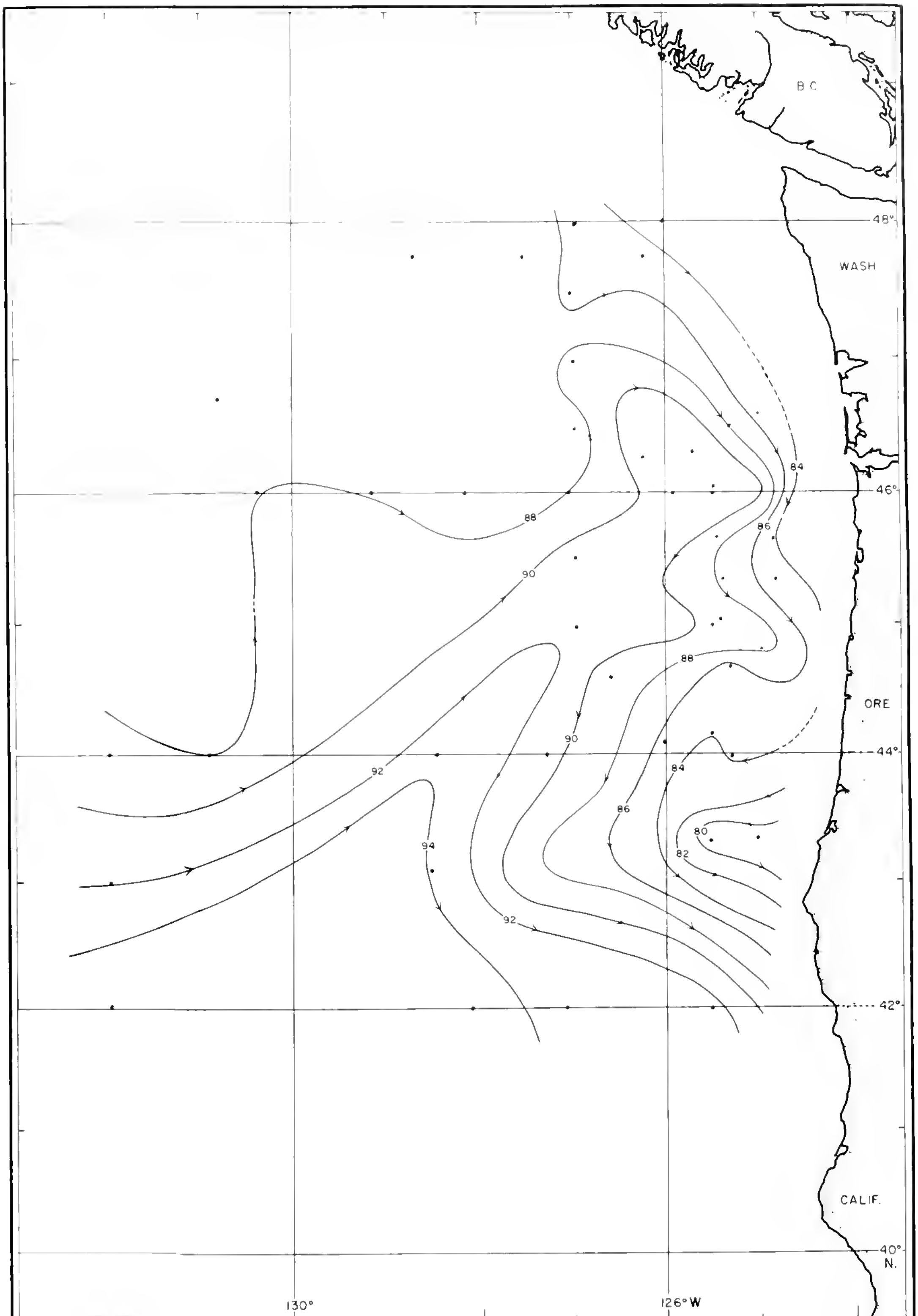

Figure 66.--Geopotential topography of the sea surface relative to 500 decibars, July 1961. Contour interval is 2 dynamic cm.

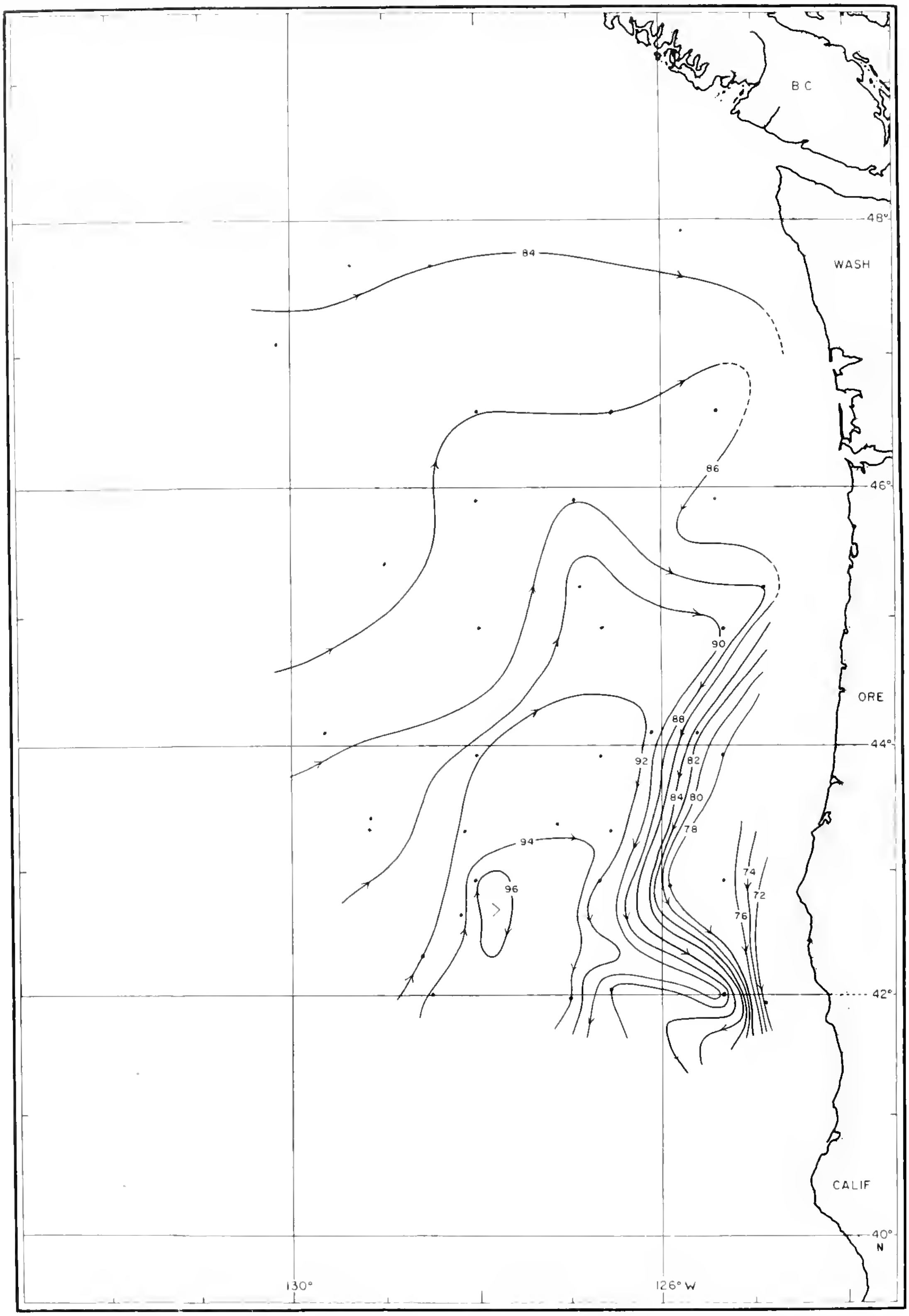

Figure 67.--Geopotential topography of the sea surface relative to 500 decibars, July 1962. Contour interval is 2 dynamic cm.

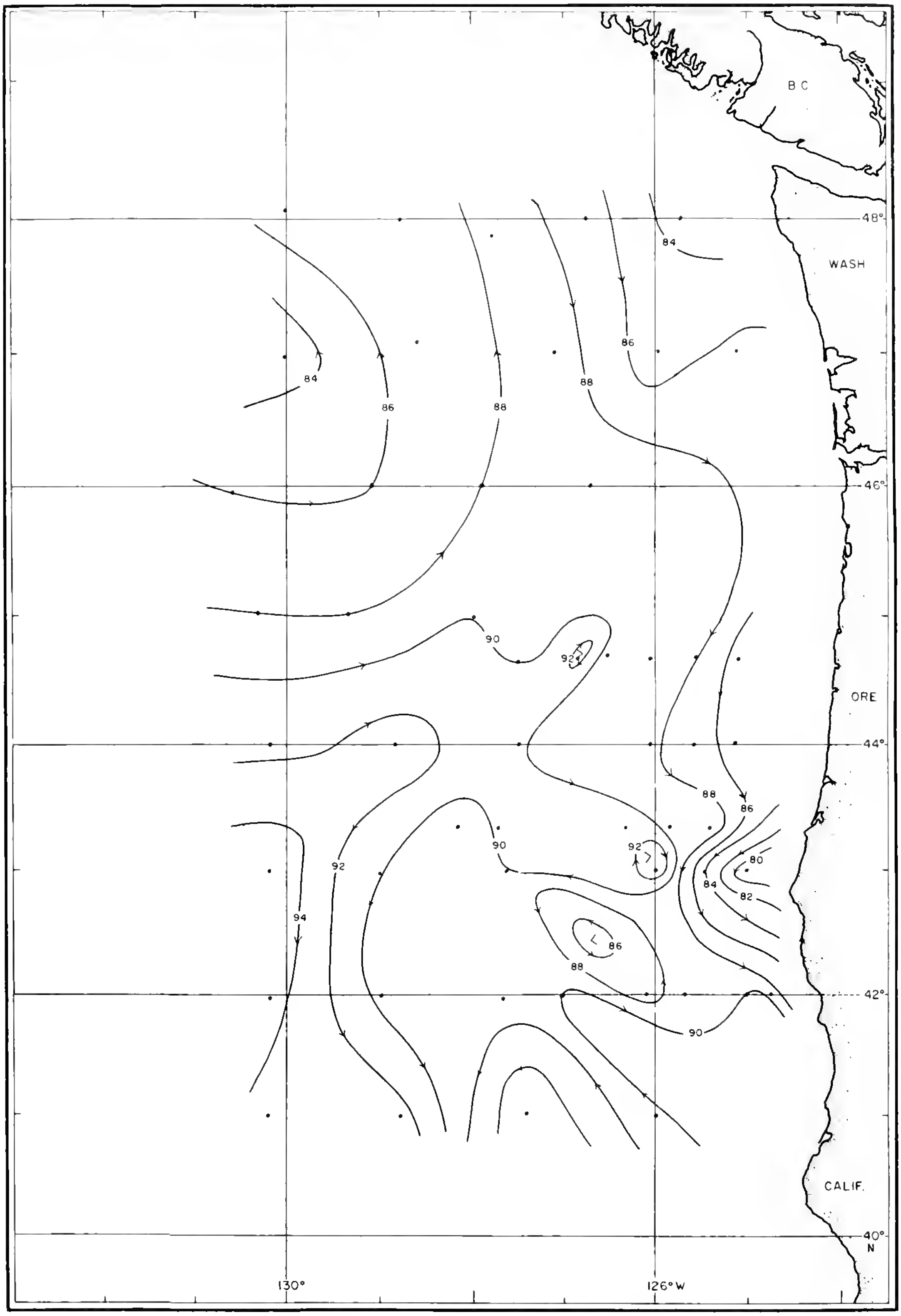

Figure 68.--Geopotential topography of the sea surface relative to 500 decibars, July 1963. Contour interval is 2 dynamic cm.

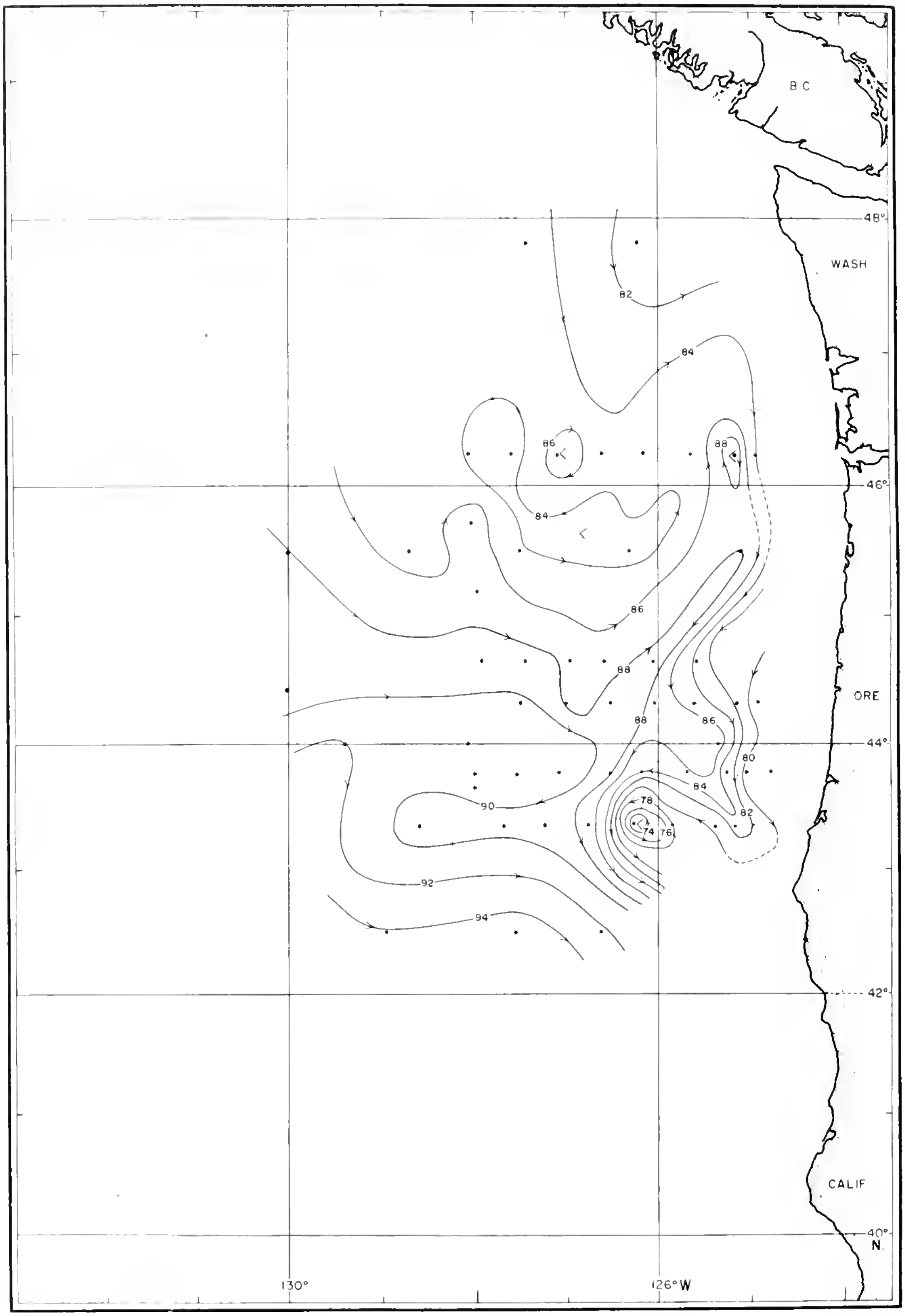

Figure 69.--Geopotential topography of the sea surface relative to 500 decibars, July 1964. Contour interval is 2 dynamic cm.

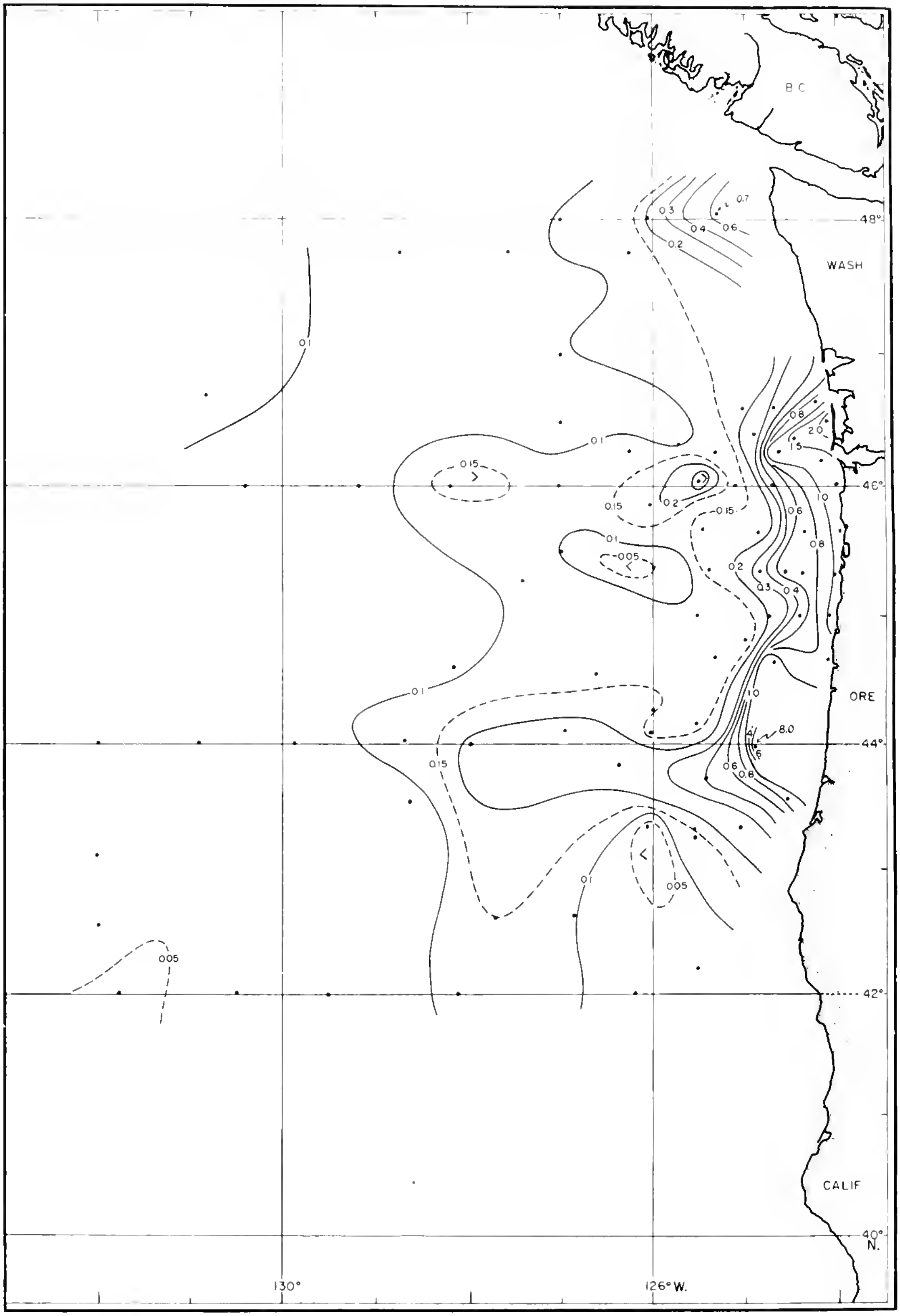

Figure 70.--Distribution of chlorophyll a concentration at the sea surface, July 1961. Contour interval (between solid lines) is 0.1 mg./m^3.

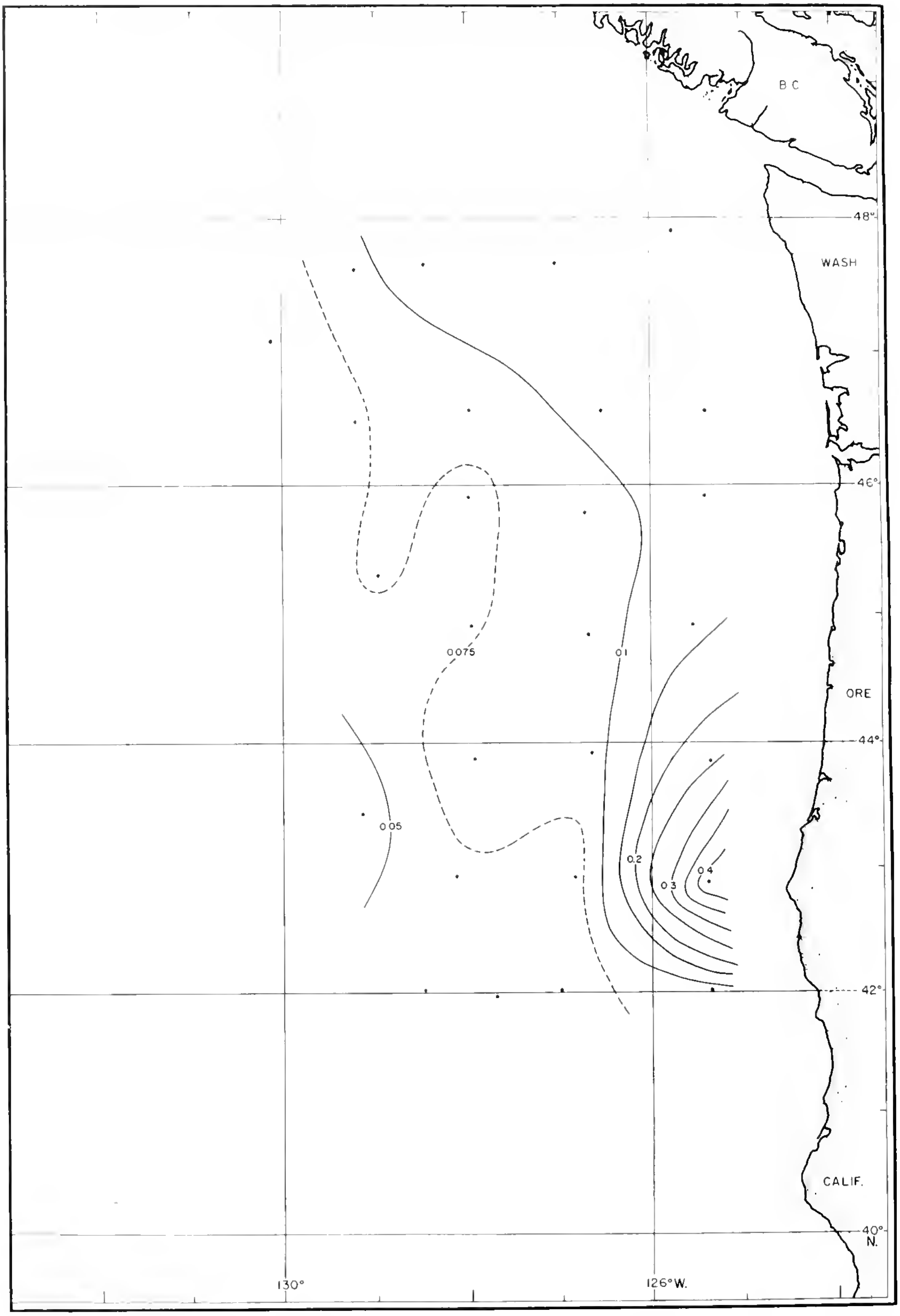

Figure 71.--Distribution of chlorophyll a concentration at the sea surface, July 1962. Contour interval (between solid lines) is 0.1 mg./m^3.

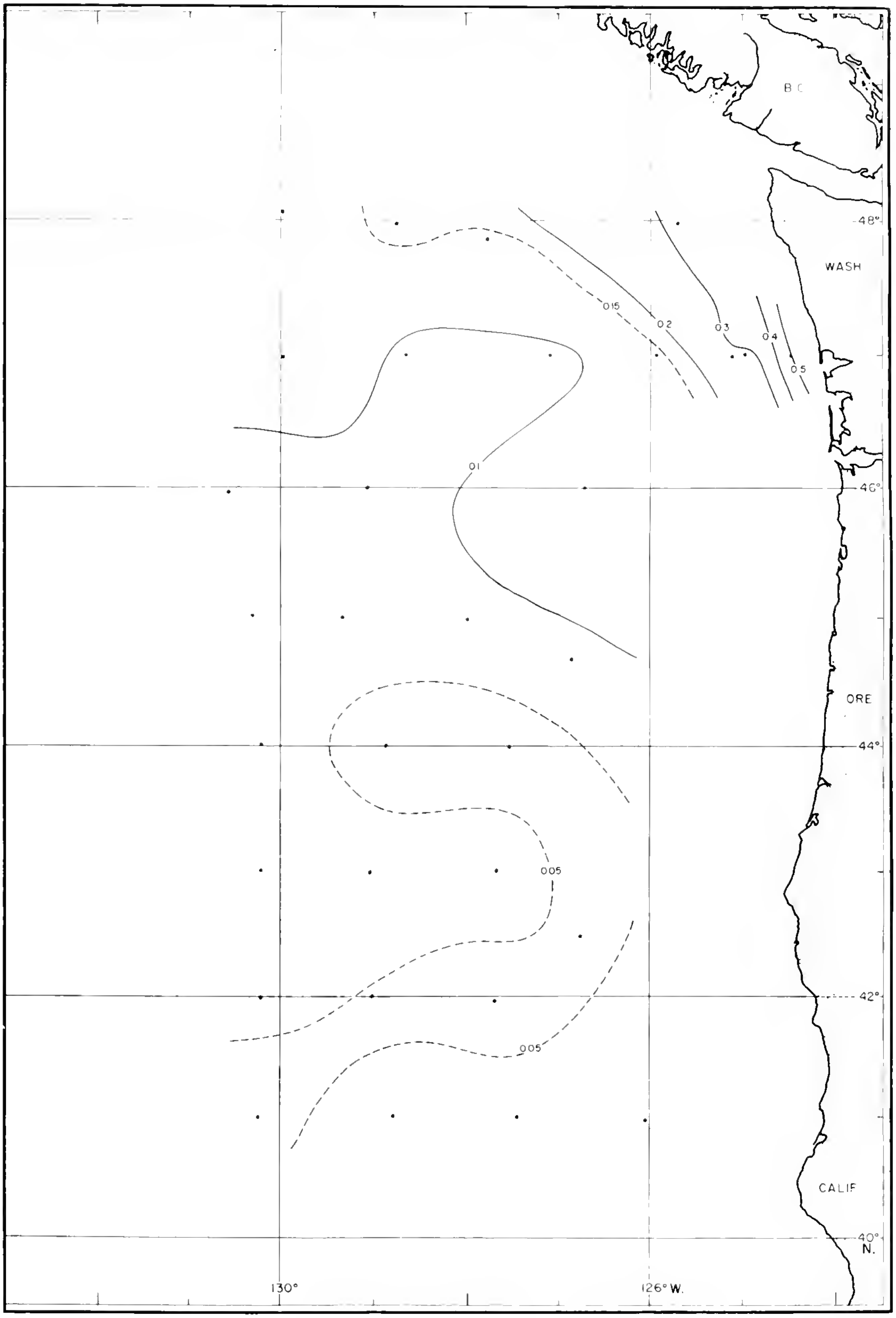

Figure 72.--Distribution of chlorophyll a concentration at the sea surface, July 1963. Contour interval (between solid lines) is 0.1 mg./m^3.

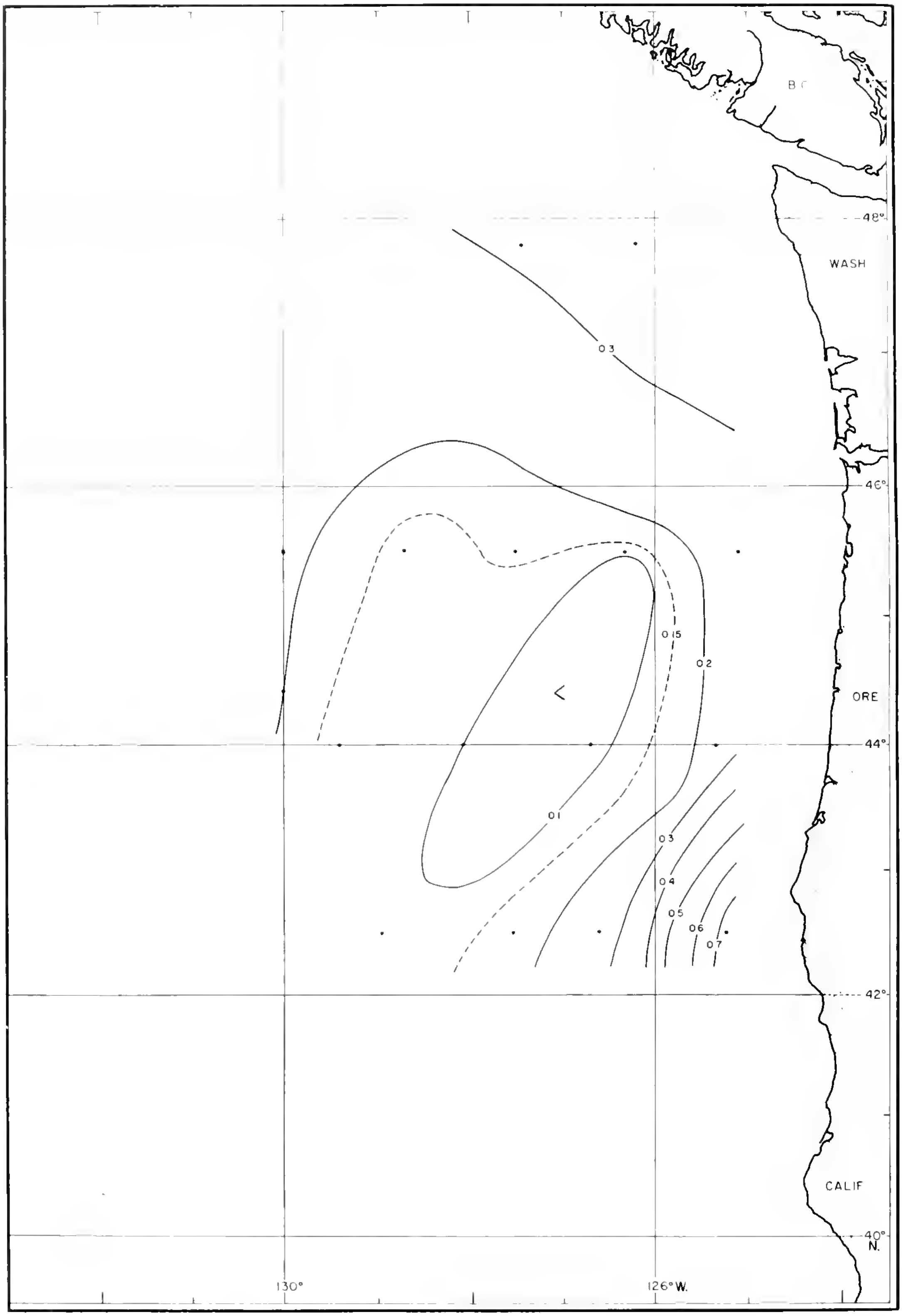

Figure 73.--Distribution of chlorophyll a concentration at the sea surface, July 1964. Contour interval (between solid lines) is 0.1 mg./m^3.

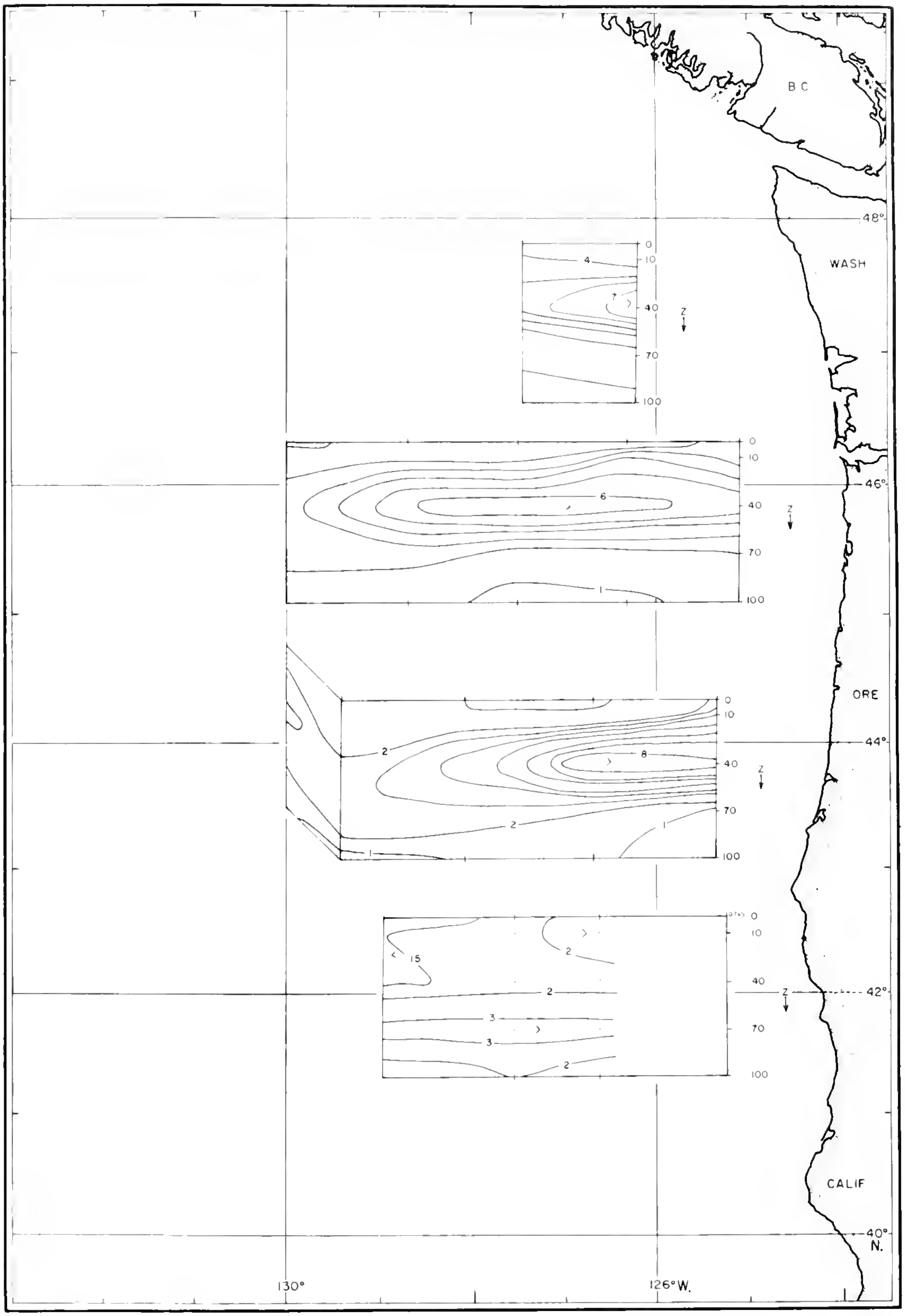

Figure 74.--Vertical profiles of chlorophyll a concentration, July 1964. Profiles are along track lines represented by uppermost line of each section. Contour interval is 0.1 mg./m^3.

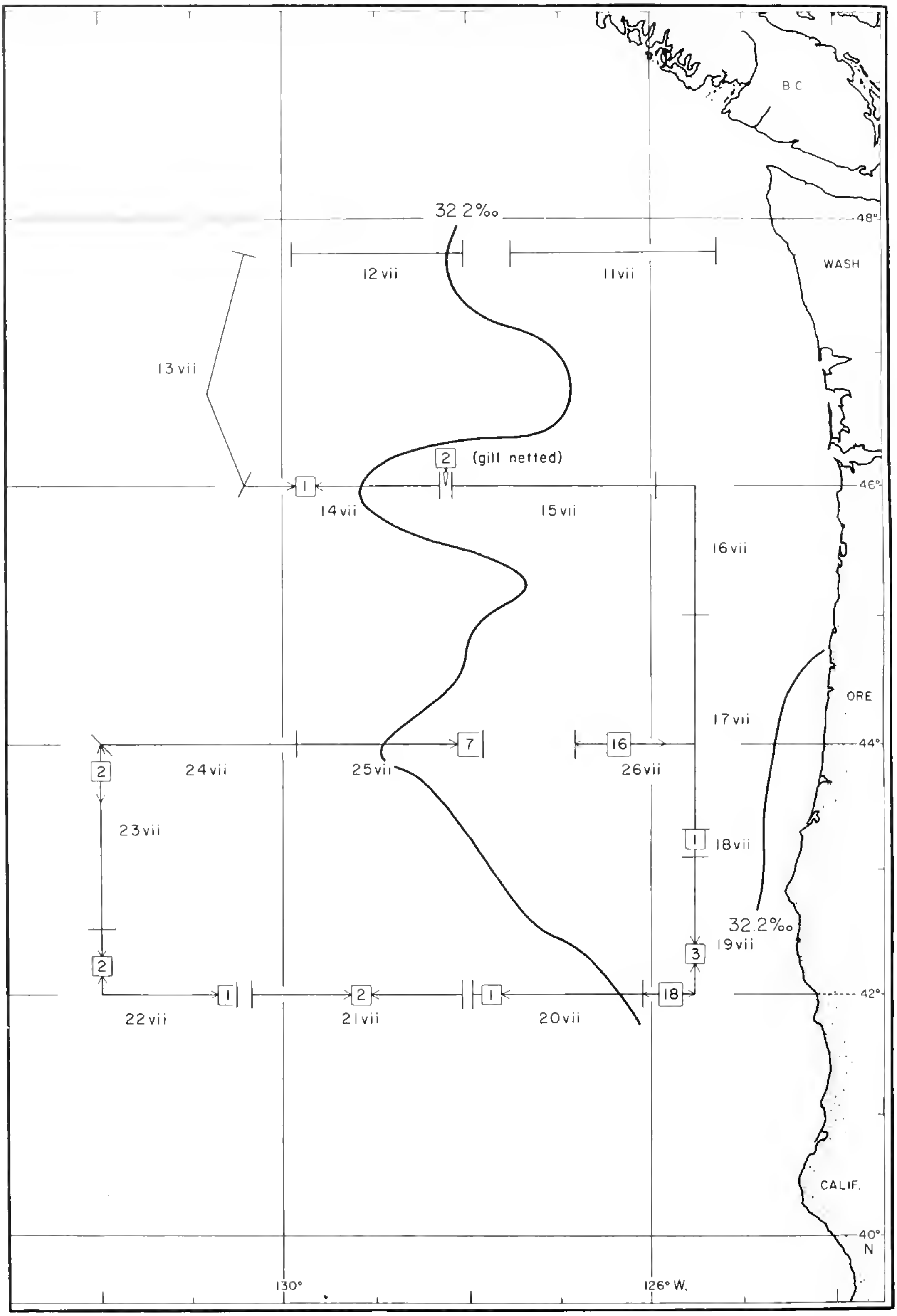

Figure 75.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1961. Day and month given below or beside track line segments.

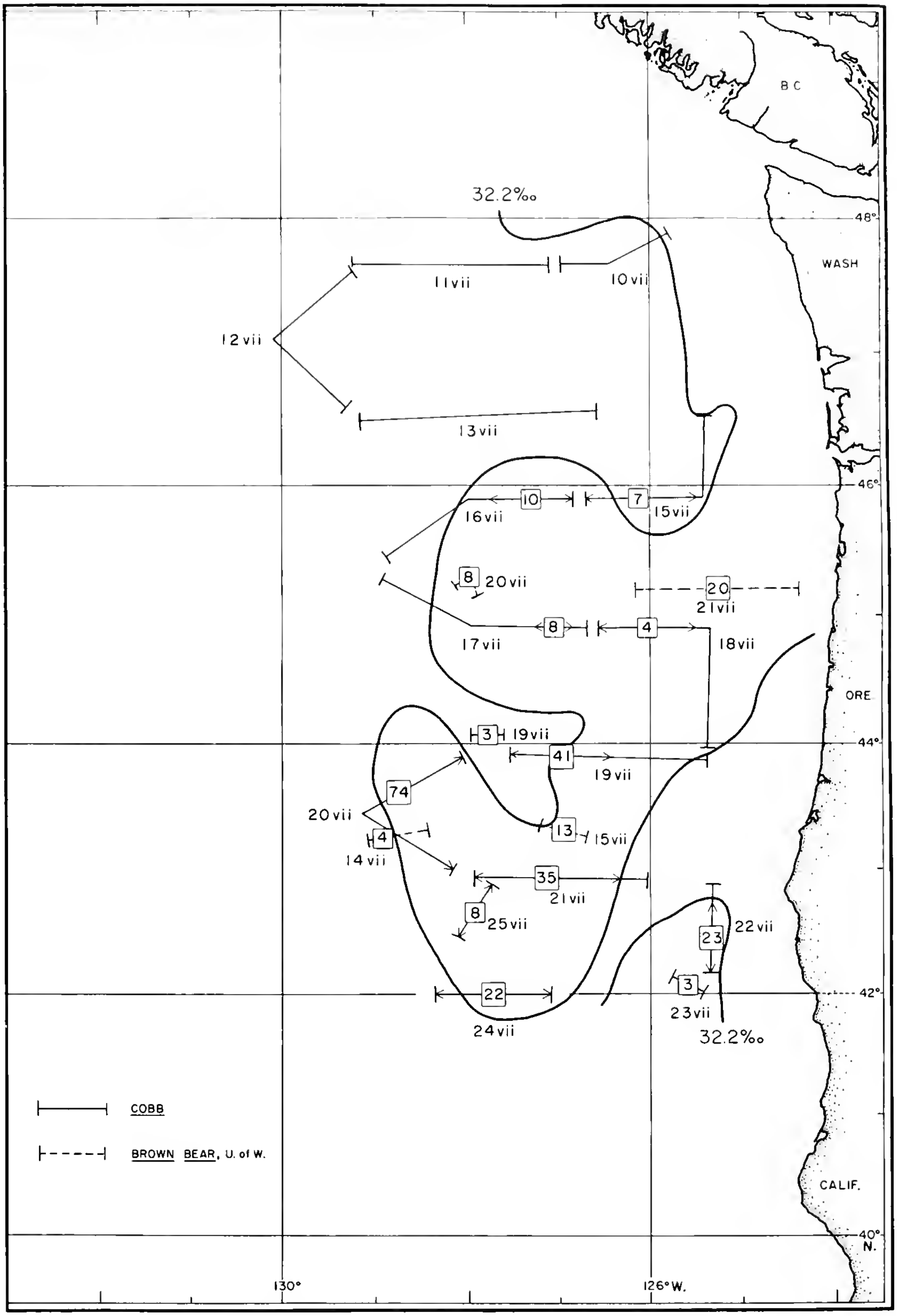

Figure 76.--Albacore catches (boxed numerals) by M/V John N. Cobb and R/V Brown Bear and lateral plume limits (32.2 p.p.t. isosal) in July 1962. Day and month given below or beside track line segments.

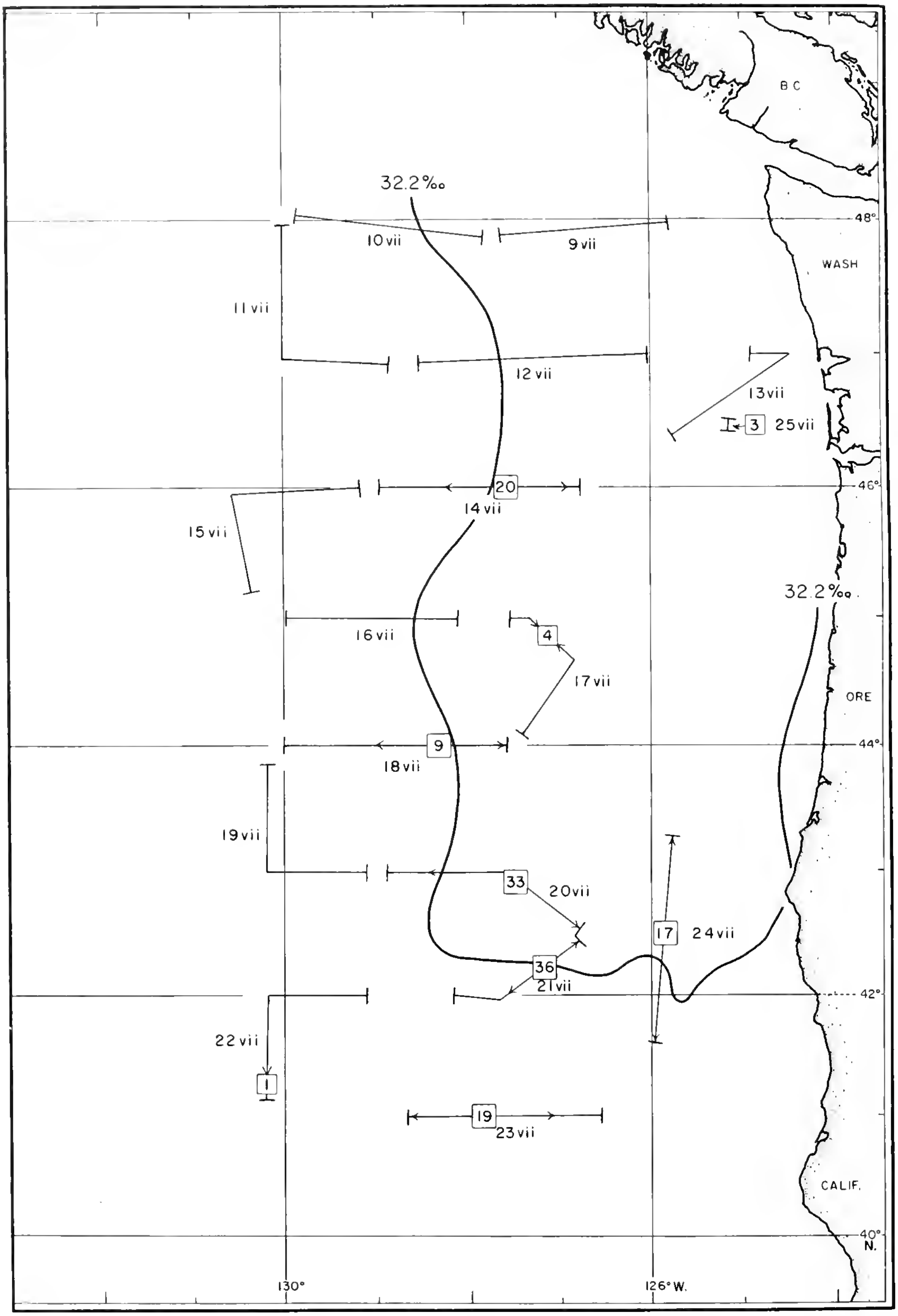

Figure 77.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1963. Day and month given below or beside track line segments.

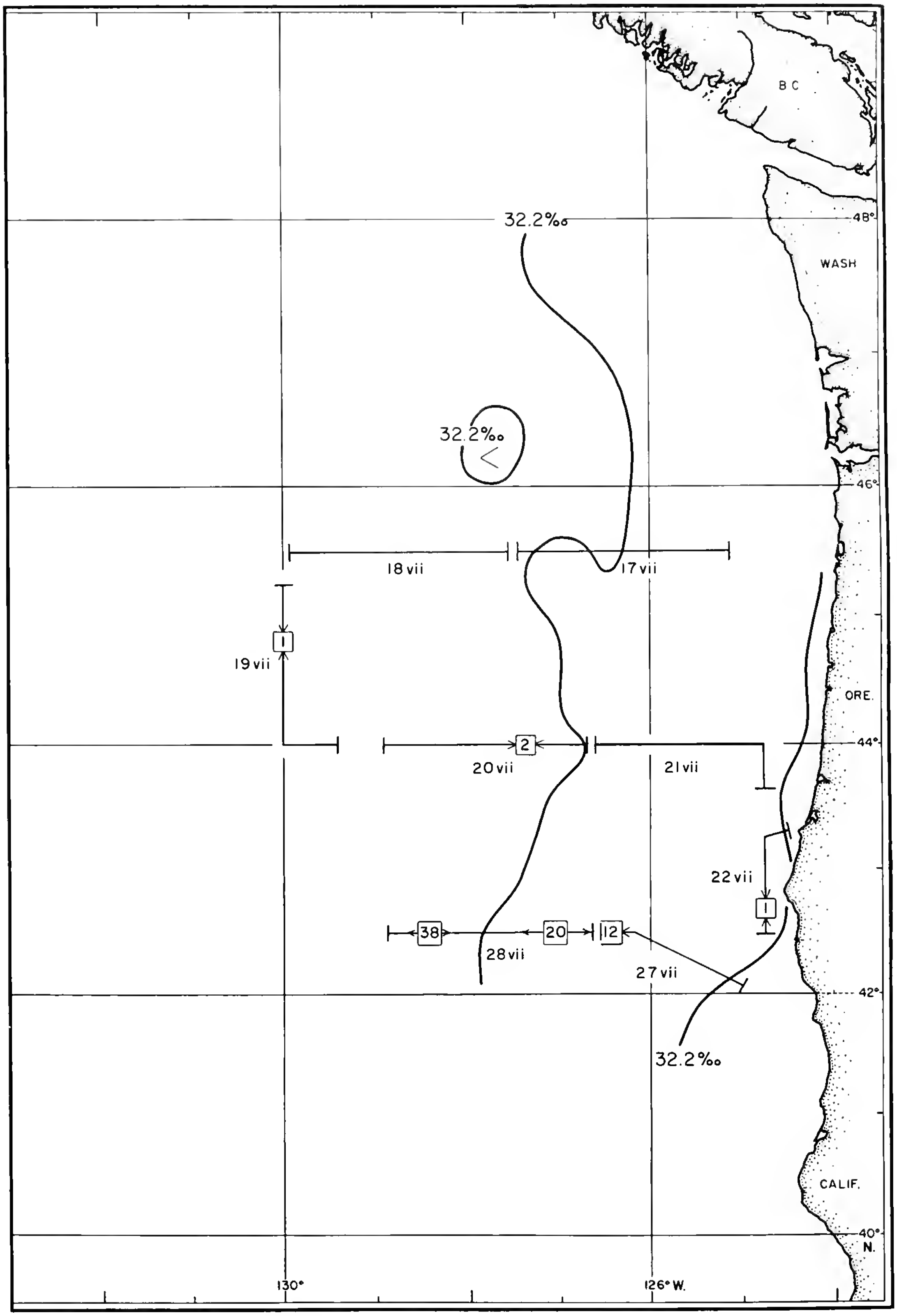

Figure 78.--Albacore catches (boxed numerals) by M/V John N. Cobb and lateral plume limits (32.2 p.p.t. isosal) in July 1964. Day and month given below or beside track line segments.

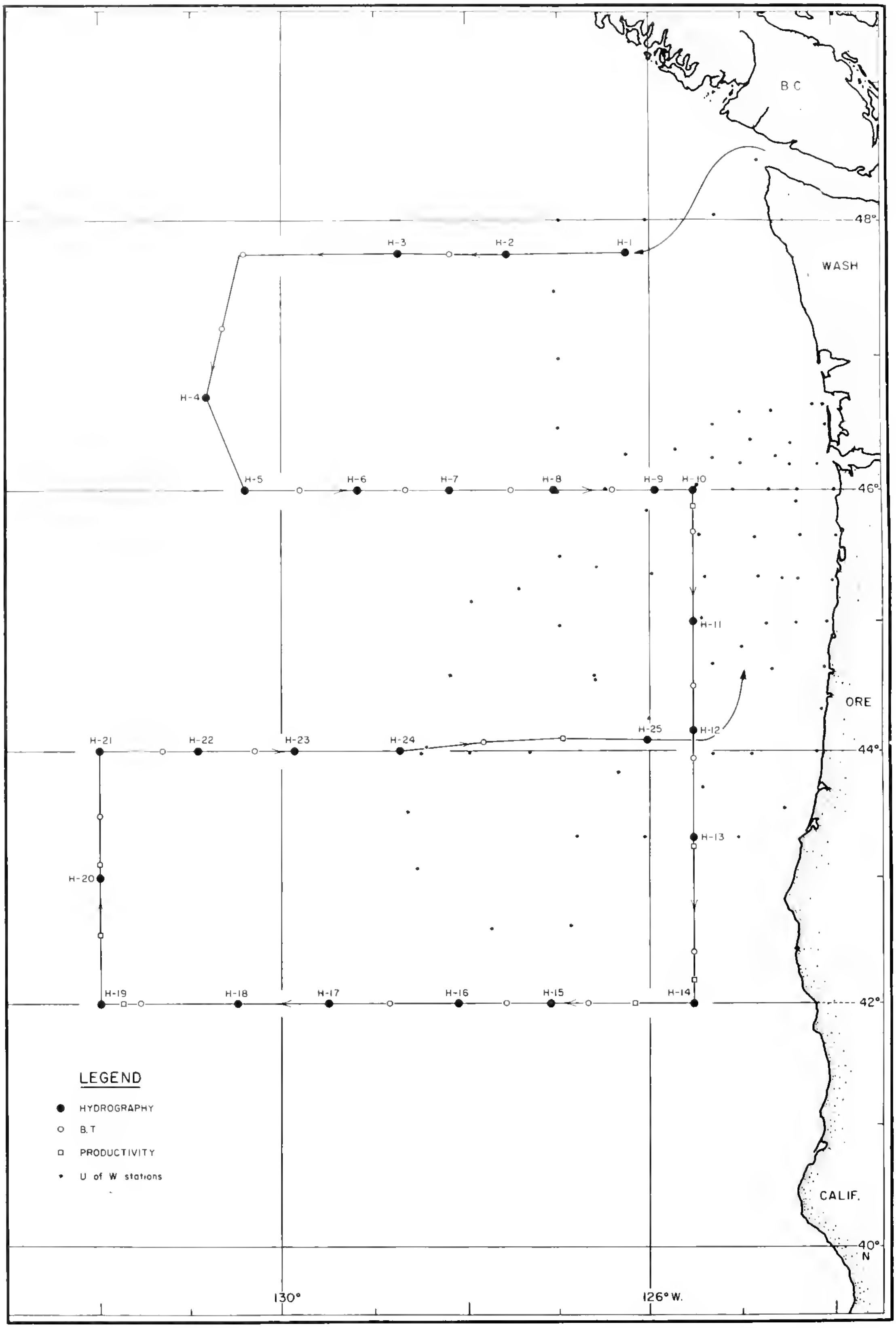

Figure 79.--Cruise track and station locations on M/V John N. Cobb Cruise 51, July 1961.

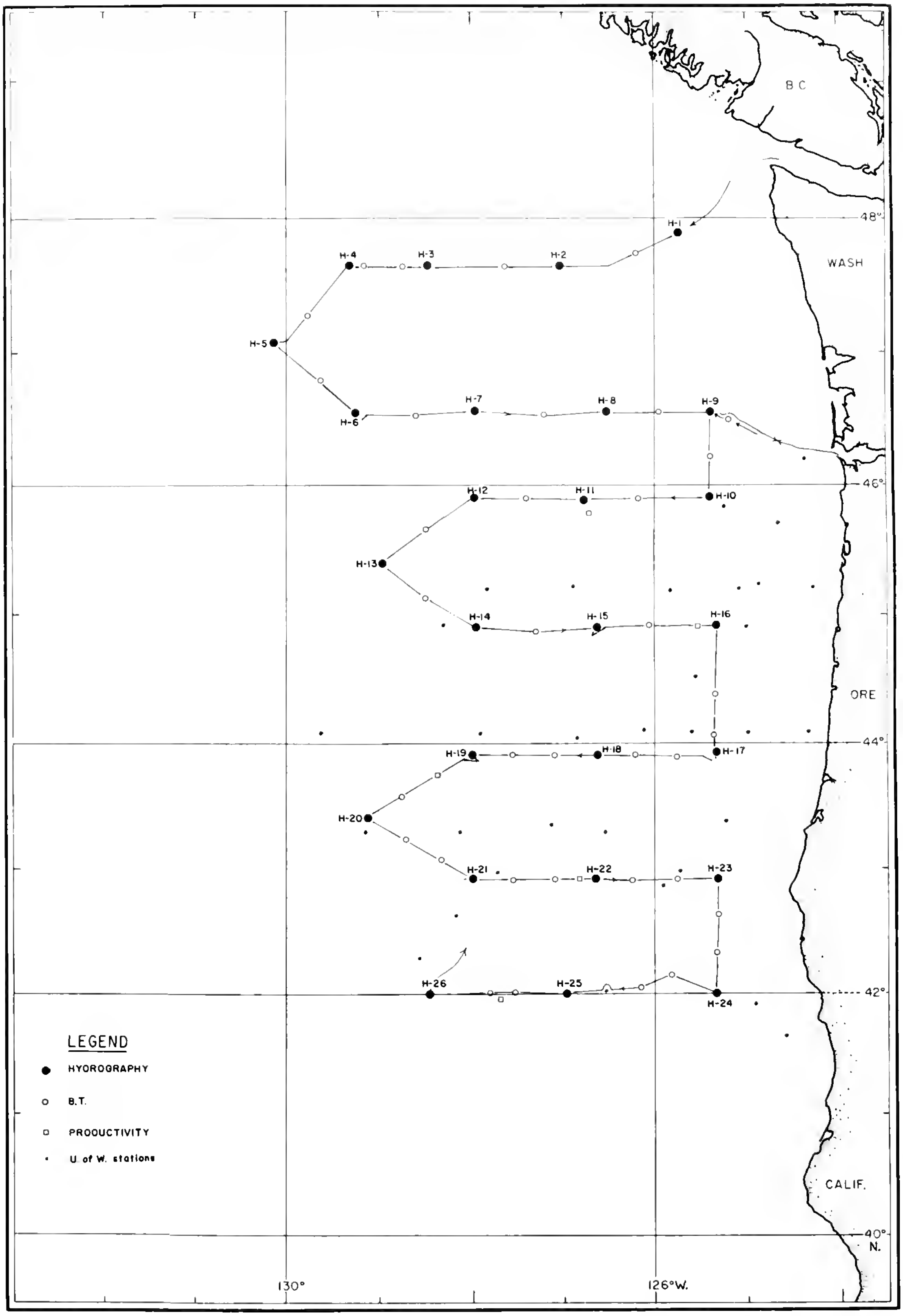

Figure 80.--Cruise track and station locations on M/V John N. Cobb Cruise 55, July 1962.

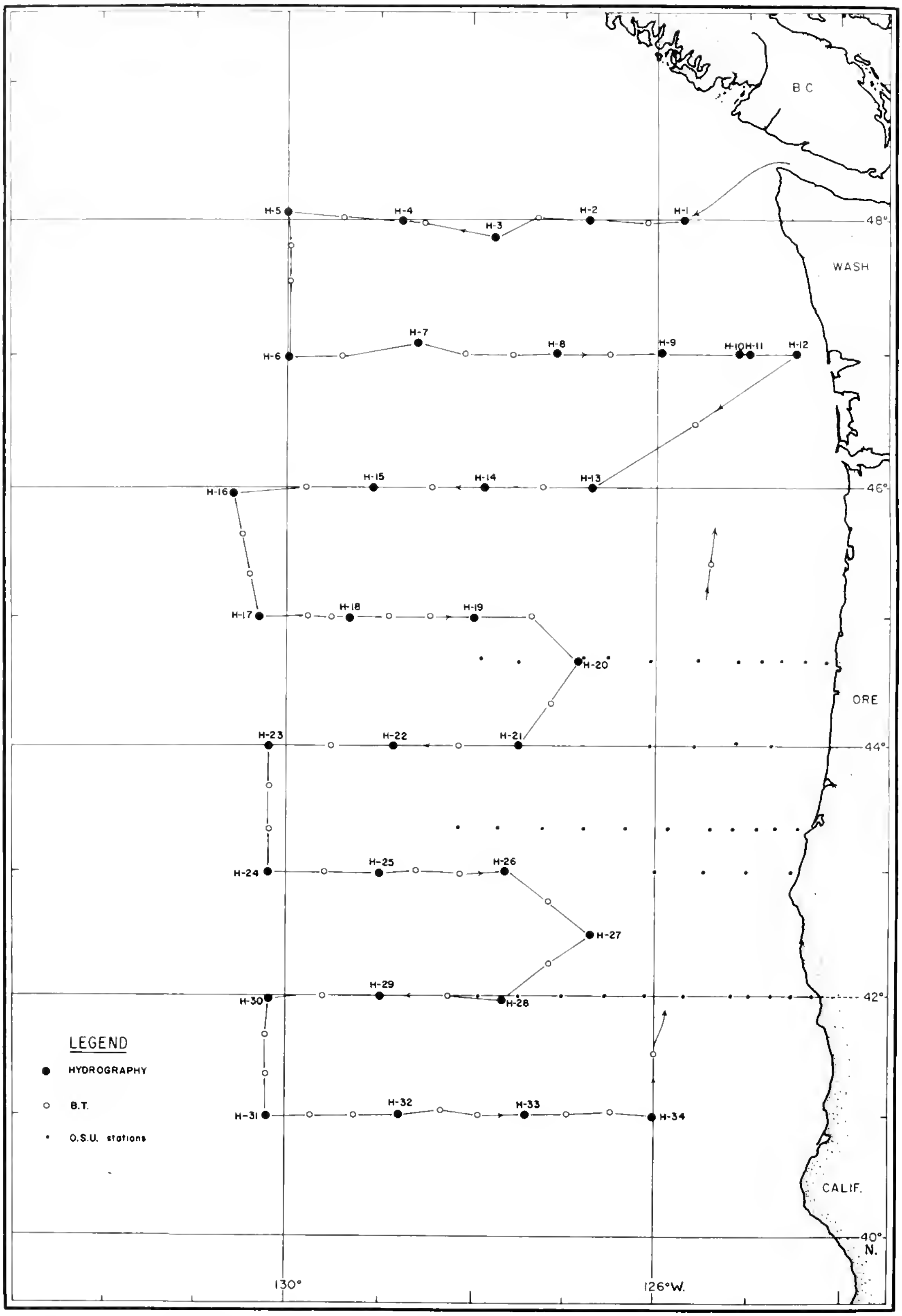

Figure 81.--Cruise track and station locations on M/V John N. Cobb Cruise 60, July 1963.

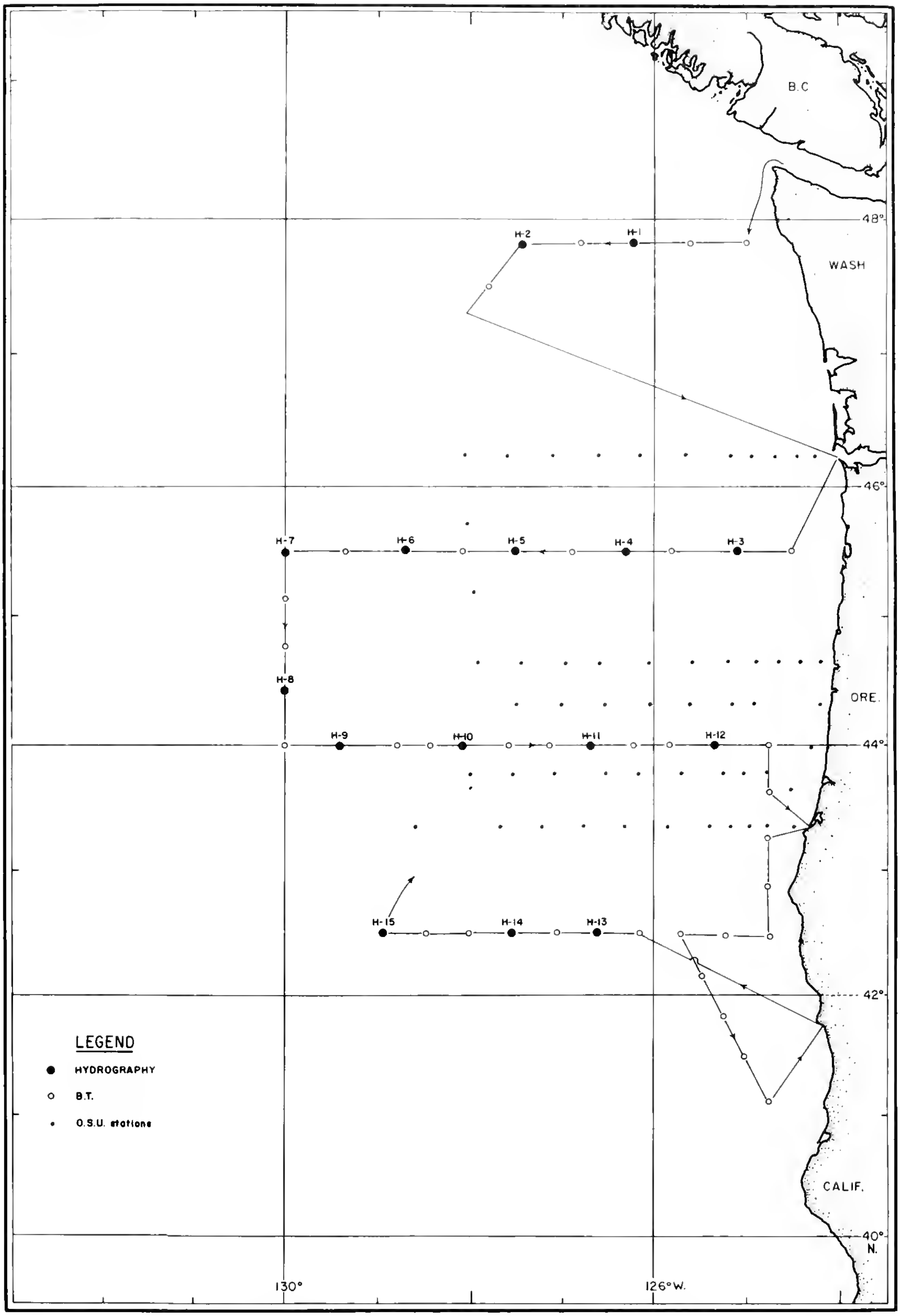

Figure 82.--Cruise track and station locations on M/V John N. Cobb Cruise 66, July 1964.

MS #1592

GPO 914-426

Created in 1849, the Department of the Interior--a department of conservation--is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D.C. 20240

OFFICIAL BUSINESS

Return this sheet to above address, if you do NOT wish to receive this material ☐, or if change of address is needed ☐ (indicate change including ZIP Code).

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR

Librarian
Marine Biological Lab.,
Woods Hole, Mass. 02543

SSR 7